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Executive Director: EUNICE THOMAS MINER

COMMUNICATION TO THE MEMBERSHIP

After thorough investigation and careful deliberation by the appropriate Committees, it was the decision of the Council to raise the annual membership dues from $15.00 to $25.00. Since this may have come as a surprise to some of our Members, we want now to give you a full picture of the Academy's activities and the privileges to each Member as well as a glance at the expenses involved to make possible these services.

The inflationary conditions now prevailing are one of the causes of the necessity for raising the dues. This phenomenon is not unique to our Academy. There is probably no one important association, society, or institution that has not raised its dues in the past several years; or that is not contemplating such a decision. We resisted the increase as long as it was possible and only yielded because there was no other way by which it was possible to maintain the high standards and proper activities of the Academy.

The Academy, like all other institutions and organizations, is subject to the economic, inflationary conditions that are prevailing also, i.e., increases in costs of materials, labor and utilities services, in addition to the increase in publication costs and the greater requirements of scientists for reimbursement of expenses attendant upon participation at most meetings, the increase in the rates of Active dues should not seem an improper and inadequate adjustment to all concerned and interested in the continuance of the Academy's program of activities.

A study has been made of the average number of publications requested by each member from a total of 36 monographs offered by the Academy in 1958; a list that with the *Transactions,* offered the Membership 8,541 text pages for 1958, alone. It was learned that the average request was for 21 of the 36 monographs offered.

Without including the overhead cost of the Building, expenses of the conferences and related expenses, but including the cost of editing and its attendant costs, mailing, and prime printing costs (*Annals* and *Transactions*), the *Annals* publications average $2.50 each copy and the *Transactions,* eight numbers, $5.00 per volume (or slightly more than sixty cents per number). This is not excessive in view of the outstanding caliber of the editing and the high quality of the printing and paper of all publications of the Academy.

The total cost to edit, publish, and mail to each Member the average of twenty-one requested monographs, therefore, if charged only within these stated categories of preparation, would be $52.50. If ordered at list prices, without mailing and handling charges, those requested at the average of the list price would amount to a total of $122.75. Membership privileges also include regular mailings of conference programs,

Monthly Programs, and the maintenance of a competent staff to keep records, and to carry out the services to Members consistent with the high scientific objectives of the Academy. The dues of the Academy are also tax exempt.

It is basic that all the Academy's conferences be of the highest scientific importance for the Academy's prestige through the years has resulted from this fundamental aim. The Conference Organization Committee, which is composed of outstanding specialists in the various fields, is keenly aware of this principle and has adopted very high standards which must be met in order to obtain its approval of a proposed conference.

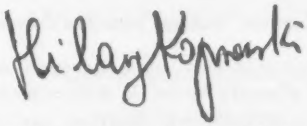
In addition, the Academy maintains a continuously efficient, prompt service through the employment of a competent, courteous staff that accomplishes its work much more because of devotion and loyalty than for any high remuneration because our salaries, too, are very much lower than those of outside business standards.

The Academy is most sympathetic with those Members, who by force of location, cannot personally always attend conferences but a strong effort is made to fill this vacuum by supplying publication on conferences to Members in the shortest possible time, and on subjects of present-day importance and pertinent to the interests of those scientists to whom high standards and progressive development holds attraction.

The Academy as an institution has been achieving the seemingly impossible in its broad program of activities and has initiated and carried through to success a large number of projects in the last twenty-four years. In 1935, it had only 317 Members, but $6,024.00 in income, and no home of its own. The bold steps it has taken during these years have sometimes been considered a disadvantage to the Academy beforehand only to become of greater advantage to science and all concerned in the end. The success of the Academy has seemed, at times, to border on the spectacular and yet, with the passing of time, such activities as have aroused comment, often unduly, have not only become the commendable and acceptable procedures but also invariably these, as in the case of the conferences initiated by the Academy, have been adopted by other institutions seeking inspiration and solution toward improving their own welfare. The Academy, as with scientists, must recognize no deterrent in furthering its opportunities for promoting the welfare and advancement of Science.

Each Member of the Academy, however, may rest assured that his financial, as well as scientific interests, are closely guarded by the Council and the Executive Director of the Academy and that every possible economy, consistent with the high scientific objectives of the Academy, is being and will continue to be effected.

We hope that after having read this explanation, each Member of the Academy will understand the necessity and will wholeheartedly subscribe to the decision of the Governing Board.



Hilary Koprowski, President
THE NEW YORK ACADEMY OF SCIENCES

SECTION OF GEOLOGICAL SCIENCES

STRUCTURAL CLASSIFICATION OF THE SHEET SILICATE MINERALS*

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It is the purpose of this paper to present a simple classification of the sheet silicate minerals based on their structural features. Plastic atomic models and two-dimensional diagrams are used to illustrate four fundamental structural types. Twelve basic structures are derived from these (TABLE 1). Known sheet silicate minerals may be related to the members of this table by structural similarity and compositional difference.

As generally recognized, the basic unit of the sheet silicates is the tetrahedral sheet (FIGURE 1). It consists of silica and, in some cases, silica and alumina tetrahedra linked together. The different members of the sheet silicate group of minerals consist of these tetrahedral sheets with various intercalated cationic and hydration layers.

FIGURE 2 shows photographs of plastic atomic models illustrating the structures of key minerals—antigorite, talc, phlogopite, and chlorite—that represent four fundamental arrangements. FIGURE 3 shows projections on the (010) plane for the same structures. In the antigorite structure each tetrahedral sheet is bound to a layer of magnesium ions octahedrally coordinated with hydroxyl ions. All of the tetrahedra point in the same direction. The talc structure consists of two tetrahedral sheets with octahedrally coordinated magnesium ions sandwiched between them. The tetrahedra in the two sheets point toward the magnesium ions. The phlogopite structure resembles talc, but approximately one aluminum atom substitutes for every fourth silicon atom in the tetrahedral sheet. This produces a net negative charge on the silicate sheets balanced by potassium ions filling the space between the sheets to form the intersilicate layer. Chlorite is similar to phlogopite except that the intersilicate layer consists of magnesium and aluminum ions hydrated with hydroxyl ions. The height of the unit cell is the most important and most diagnostic feature of each of these structural types.

The 4 minerals discussed above are trioctahedral; that is, 3 positions available in the octahedral layer are filled with 3 magnesium ions. If the octahedral layer is occupied by aluminum ions, only 2 of the sites are filled, and the mineral is dioctahedral. The charge in each case is the same, since the magnesium ions are divalent and fill 3 positions, while the aluminum ions are trivalent and fill 2 positions. This is considered an important structural feature of the sheet silicates, and serves as a basis for dividing them into 2 groups in TABLE 1.

*This paper, illustrated with slides, was presented at a meeting of the Section on April 6, 1959.

TABLE 1

REPRESENTATIVES OF THE BASIC SHEET SILICATE STRUCTURES

Dioctahedral	*Trioctahedral*	C_0
Three-layer type		
Montmorillonite $Na_{0.3}(H_2O)_xAl_2(OH)_2(Al_{0.3}Si_{3.7})O_{10}$	Saponite $Na_{0.3}(H_2O)_xMg_3(OH)_2(Al_{0.3}Si_{3.7})O_{10}$	12 – 21A
	Mg-vermiculite $Mg_{0.5}(H_2O)_xMg_3(OH)_2(Al, Si_3)O_{10}$	14A
	Mg-chlorite (clinochlore) $Mg_2Al(OH)_6Mg_3(OH)_2(Al, Si_3)O_{10}$	14A
Muscovite $KAl_2(OH)_2(Al, Si_3)O_{10}$	Phlogopite $KMg_3(OH)_2(Al, Si_3)O_{10}$	10A
Pyrophyllite $Al_2(OH)_2(Si_4)O_{10}$	Talc $Mg_3(OH)_2(Si_4)O_{10}$	9.4 A
Two-layer type		
Kaolinite $Al_4(OH)_8(Si_4)O_{10}$	Mg-antigorite $Mg_6(OH)_8(Si_4)O_{10}$	7.3 A
Two-layer tube structure		
Halloysite $Al_4(OH)_8(Si_4)O_{10}$	Mg-chrysotile $Mg_6(OH)_8(Si_4)O_{10}$	

This classification is based on structural similarity and compositional difference; hence, the structural formula becomes the most useful means for tagging the minerals. Unfortunately, there has been much inconsistency in the use of structural formulas in the literature. Thus a consistent format indicating structural relationships appears desirable. A format is suggested and phlogopite and muscovite formulas are given to illustrate the way in which it represents structure and composition.

Phlogopite: $K\,Mg_3\,(OH)_2\,(Al, Si_3)O_{10}$

Muscovite: $K\,Al_2(OH)_2\;\;(Al, Si_3)O_{10}$

Intersilicate	*Octahedral*	*Tetrahedral*
K	$Mg_3\;\;(OH)_2$	$(Al, Si_3)\;O_{10}$
K	$Al_2\;\;(OH)_2$	$(Al, Si_3)\;O_{10}$

In the structural formulas suggested here the components at the right end are tightly bound, while those at the left are more loosely bound. In many of the sheet silicates the constituent on the extreme left is subject to ion exchange at low temperatures, while the tetrahedral groups appearing at the right remain intact even after complete melting. The structural formula also shows whether the mineral is dioctahedral or trioctahedral.

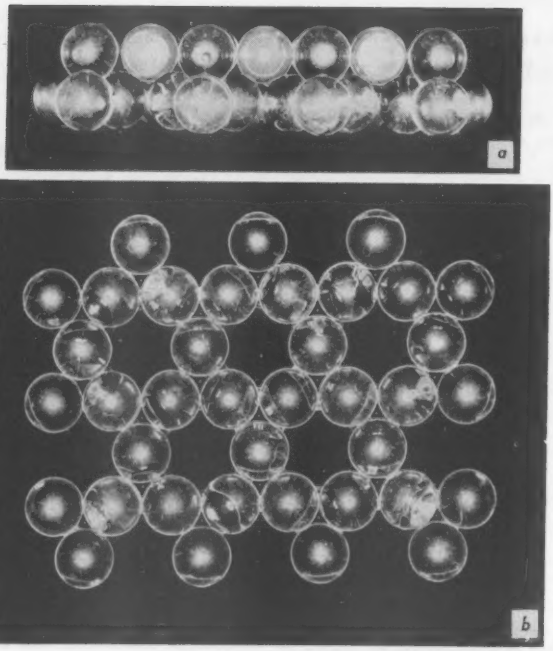

FIGURE 1. Plastic atomic model of the silicate tetrahedral sheet: *(a)* side and *(b)* base.

The formulas in TABLE 1 are idealized, but considerable deviation in composition can and does take place. In a classification it is important to arrange ideal members before attempting to define real or deviant members.

In TABLE 1 three additions have been made to the four fundamental trioctahedral minerals. These are saponite, Mg-vermiculite, and Mg-chrysotile. Mg-vermiculite is similar to Mg-chlorite except for the intersilicate layer. In vermiculite the intersilicate layer consists of magnesium ions hydrated with H_2O molecules rather than OH ions. The H_2O molecules introduce no negative charge, whereas the OH ions do. As a result, there are fewer magnesium ions in the intersilicate layer of vermiculite than in the intersilicate layer of chlorite.

Saponite, the magnesian member of the montmorillonite group, differs from vermiculite in that the net negative charge on the silicate layer is lower and, as a result, the cationic population of the intersilicate layer is lower than in vermiculite. The low net negative charge may result either from a low Al/Si ratio in the tetrahedral layer or from substitution and omission in the octahedral layer. A wide variety of cations can enter the

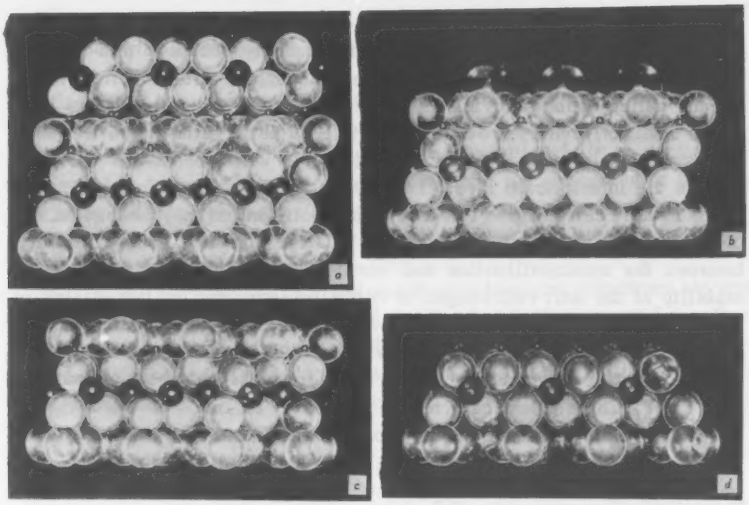

FIGURE 2. Plastic atomic models of the four fundamental sheet silicate structures: *(a)* chlorite; *(b)* phlogopite; *(c)* talc; and *(d)* antigorite.

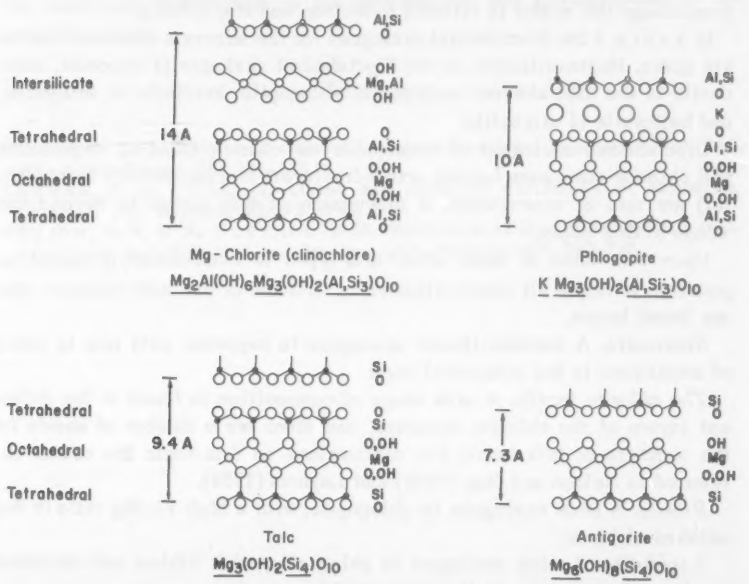

FIGURE 3. B-axis projections of the four fundamental sheet silicate structures.

intersilicate layer of saponite and other members of the montmorillonite group. Sodium is given here because it commonly occupies this position and also because some workers convert montmorillonite minerals to the sodium variety when studying them. The cations in the intersilicate layer of the montmorillonites are hydrated with H_2O as in vermiculite. However, the low cationic content permits considerable variation in the amount of H_2O in the intersilicate layer. This variation is responsible for the wide range in unit cell height (12A-21A). Montmorillonites may change in unit cell dimension even with changes in relative humidity. The distinction between the montmorillonites and vermiculites is usually based on the stability of the unit cell height. If it can be increased by introducing organic molecules, the mineral is considered to be a montmorillonite. If it remains stable at 14A, the mineral is considered to be vermiculite.

Mg-chrysotile has also been added to the trioctahedral sheet silicates in TABLE 1. Chrysotile fibers result from the "curling" of the antigorite sheet due to the asymmetry of the two-layer structure. The two-layer structure in chrysotile has "curled" to such an extent that it forms a tube. Such curvature of the sheets has been found in antigorite, where it tends to produce waves rather than tubes. The reader is referred to Eitel (1958) for a discussion of wave and tube features. Septechlorite is another term that has been applied to the two-layer type structures. For a discussion of this terminology the reader is referred to Nelson and Roy (1958).

In TABLE 1 the dioctahedral analogues for the minerals described above are given. Montmorillonite is the dioctahedral analogue of saponite, muscovite is the dioctahedral analogue of phlogopite, kaolinite of antigorite, and halloysite of chrysotile.

Dioctahedral analogues of vermiculite and chlorite (that is, vermiculite and chlorite structures having octahedral layers that are entirely dioctahedral) are rare or nonexistent. A discussion of this matter is beyond the scope of this paper.

Once this table of basic structural types is established, it should be possible to relate all sheet silicates to it. Some of the more common ones are listed below.

Nontronite. A montmorillonite analogous to saponite, with iron in place of magnesium in the octahedral layer.

The chlorite family. A wide range of composition is found in the different layers of the chlorite structure, and there are a number of names for the members of this family. For discussions on this topic the reader is referred to Nelson and Roy (1958) and Lapham (1958).

Biotite. A mica analogous to phlogopite, with a high Fe/Mg ratio in the octahedral layer.

Lepidolite. A mica analogous to phlogopite, with lithium and aluminum in place of magnesium in the octahedral layer.

Paragonite. A mica analogous to muscovite, with sodium substituting for potassium in the intersilicate layer.

Margarite. A mica analogous to muscovite, with calcium in the place of potassium in the intersilicate layer and having an Al/Si ratio of 2/2 in the tetrahedral layer.

Illite. This term refers to clay-sized mica of a wide range of compositions. The intersilicate cation population may be somewhat lower than that of megascopic mica, but if the cation population falls to a point sufficiently low to permit the entrance of water and the expansion of the lattice, then the mineral is generally considered montmorillonite.

Zinnwaldite. A mica analogous to phlogopite, with lithium, iron, and aluminum in the octahedral layer.

The plastic models used to illustrate the fundamental structures are constructed of solid methacrylate (Plexiglas-Lucite) balls cemented together with Duco cement. The sizes of the balls were selected to permit the oxygens in the tetrahedral sheet to be in contact with each other. This necessitated the use of a radius ratio of silicon to oxygen somewhat less than the recognized ratio, but gives a structure with satisfactory rigidity.

Acknowledgments

The construction of the models used in this paper was made possible by the mineralogical laboratory of Columbia University under the guidance and encouragement of Paul F. Kerr. I am indebted to Martin W. Molloy for his labor and imagination in the construction and photographing of the crystal models.

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DIVISION OF NUCLEAR PHYSICS

METEORITES IN THE LABORATORY*

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Meteorites are macroscopic bodies that travel through the solar system and occasionally collide with the earth. According to current usage, the body itself, even while it is in space, is called the meteorite, while the term meteor refers to the visual phenomenon resulting from its passage through the atmosphere. A great many meteorites occur in streams of established orbits and, in some cases, these orbits are the same as those of former comets. It is plausible that these shower meteorites, so called from the familiar meteor showers they produce – for example, the Perseids in early August and the Orionids in late October – represent the debris of comets. More puzzling are the sporadic meteorites. Most sporadic meteorites follow elliptic orbits, and are trapped within the solar system. They are probably fragments from the destruction of one or more asteroids, but conceivably might have been formed during the condensation of the solar nebula into the solar system. There is some controversy as to whether any of the sporadic meteorites follow hyperbolic paths, indicating an origin beyond the solar system.

A considerable amount of meteoritic dust falls on the earth, a reasonable estimate being 250,000 metric tons per year. This dust consists of particles from a few microns to 250 μ across, most in the vicinity of 15 μ. These particles have been found in New Mexico lake sediments, in various clays and shales, and may be separated magnetically from collected rainwater.

The familiar meteorites of museums fall into three general classes: (1) stony meteorites, most of which consist of hail-like objects called chrondules cemented in solid masses; (2) iron meteorites, which are composed of iron with some nickel also present; and (3) stony-iron meteorites, whose properties fall between the first and second classes. These meteorites are found only in geological strata of the current era and, apparently, did not begin to strike the earth until the late Quaternary – several hundred thousand years ago. This does not necessarily suggest, of course, that meteorites were *formed* only during these times.

Another category of meteorites contains the tektites, sometimes called glassy meteorites. While the falls of stone, iron, and stony-iron meteorites have been observed, there is no verifiable report of a tektite fall. The tektites are found in strata of the late Tertiary and early Quaternary periods only. They are found almost exclusively in a latitude belt around

*This paper was presented at a meeting of the Division on April 8, 1959.

the equator from about 40° N to 40° S, a fact which has been used to support an argument for their lunar origin (the earth's equatorial bulge, in this theory, would have perturbed tektite orbits about the earth subsequent to their ejection from the moon, causing them to fall near the bulge). There is still some slight support for a theory of terrestrial origin, however. All of the meteorite types are sufficiently different from terrestrial minerals to permit their unambiguous identification.

By analyzing the isotopic composition of a meteorite, it is possible to determine its age (that is, the period of time since its formation) and, independently, the amount of cosmic ray bombardment it has experienced. The age determinations may be made by any of the methods based upon the radioactive decay of long-lived isotopes, but the one that seems most practical employs the decay of K^{40}. This isotope constitutes 0.012 per cent of ordinary potassium, and may undergo either beta decay to Ca^{40} or K-capture to A^{40}. Because Ca^{40} is abundant in natural calcium and some calcium is always found in potassium-containing minerals (including meteorites), it would not be easy to distinguish between natural Ca^{40} and the Ca^{40} originating in the decay of K^{40}. The situation with respect to A^{40} is much more satisfactory, since no A^{40} is likely to be incorporated into meteoritic material at its formation. Some A^{40} might conceivably be produced in a meteorite by spallation induced by cosmic radiation, but this contribution should be undetectable. The diffusion of argon from meteorites does not occur (except in the surface layers) at temperatures much below 400° C., and most of the stony meteorites show no evidence of having experienced such temperatures since their formation. Until recently, the K-A method of dating meteorites was unworkable because the branching ratio between the two decay modes of K^{40} was poorly known. This ratio is now believed to be $A^{40}/Ca^{40} = 0.12 \pm 0.02$. Meteorite ages calculated by this method range from 10^8 to several times 10^9 years.

In its flight through space a meteorite undergoes a prolonged bombardment by cosmic rays, leading to the production of isotopes that are quite rare in nature. Some of these isotopes are either stable or have very long half-lives, and from their concentrations in meteoritic material information on the total cosmic-ray flux to which the meteorite has been exposed may be obtained. In particular, the stable isotope He^3 has proved useful; it is produced both directly and as the decay product of tritium, H^3, whose half-life is about 12 years. The long-lived isotopes Mn^{53}, Be^{10}, and Al^{26} have been suggested as possible supplements to He^3 methods, but no results with these isotopes have been reported.

Before going from He^3 concentrations to integrated cosmic-ray fluxes, it is necessary to know the cross sections for the production of H^3 and He^3 in meteoritic material by cosmic rays. These have been measured by bombarding iron targets with 2.2 Bev protons and aluminum targets with 700 Mev protons. In the former work, a tritium production cross section in

iron of 62±7 mb. was found. The latter determination, which employed an aluminum target in order to simulate the average Z of stony meteorites (whose principal constituents are oxygen, iron, silicon, and magnesium), yielded an He^3 cross section of 35 mb. Since the tritium production cross section in aluminum is 30 mb., about 55 per cent of the He^3 content of stony meteorites is produced directly. Assuming a constant cosmic-ray flux in the past – which is plausible on astrophysical grounds – the "radiation ages" of meteorites may be computed, and the result is a range of from 10^7 to more than 10^8 years. The radiation ages are indicative, of course, of the time the relatively small meteorite was directly exposed to cosmic radiation, and hence of the period that elapsed since the breakup of the parent body that shielded it from direct bombardment. Thus, radiation ages should always be less than the ages indicated by K-A and other radioactive dating methods.

As a means of checking the assumption of constant cosmic-ray intensity, the A^{39} (260 year half-life) and Cl^{36} (3×10^5 year half-life) activities present in the Sikhote Alin meteorite that fell in 1948 have been compared. From the cross sections for the production of A^{39} and Cl^{36} by high-energy particles and the observed activities of these isotopes in the meteorite, it was inferred that cosmic-ray fluxes in space have not varied by more than 10 per cent during the past 10^5 years.

Tektite ages by the K-A method range from about 10^6 to 10^7 years, so that they are considerably younger than the other meteorites. A recent search for cosmic ray-produced He^3 and Ne^{21} in an Australian tektite was unsuccessful, leading to an estimate for the maximum radiation age, that is, time of flight of 10^6 years. This figure leaves unsettled the question of extraterrestrial tektite origin, but it may be possible with improved techniques to acquire more definite information.

SECTION OF BIOLOGICAL AND MEDICAL SCIENCES

I. THE IMPORTANCE OF THE EPITHELIUM IN THE SYNTHESIS OF THE SULFATED GROUND SUBSTANCES IN CORNEAL CONNECTIVE TISSUE*

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Connective tissue consists of cells and their products, the fibers, and the ground substance. The cells of connective tissue have been regarded as functionally independent and have been shown capable of synthesizing both the mucopolysaccharides of the ground substance and collagen fibers in tissue culture. Recent evidence, however, obtained in part from studies on regeneration,[1-4] shows that the function of corneal connective tissue is to a considerable degree dependent on and interrelated with the epithelia that covers it.

The cornea is rich in mucopolysaccharide ground substances, chondroitin, chondroitin sulfate, and keratosulfate. The two sulfated materials can be labeled *in vivo* with S^{35} inorganic sulfate, and the metabolism of the mucopolysaccharides thereby followed. The synthesis and "turnover" rates of these substances have been studied both by direct counting techniques and by radioautography. Although radioautographs are not as satisfactory for quantitative measurement, they have the advantage of showing the location of the labeled substances and, if the photographic emulsion is homogeneous, quantitative data can be obtained.

The purpose of the following experiments was to determine whether the synthesis of corneal sulfated mucopolysaccharides is influenced by the presence of the epithelium.

Methods

Rats were injected subcutaneously with 1.0 mc./kg. body weight radioactive S^{35} sulfate. Sufficient quantities of sulfate were incorporated in newly formed mucopolysaccharides within 7 hours to give satisfactory autographs. The corneas were removed at autopsy and radially disposed cuts were made in the periphery so that they could be flattened. Each cornea was then washed for 3 hours in several changes of nonradioactive 0.1 M sodium sulfate solution in order to remove any remaining inorganic radioactive sulfate. The whole corneas were then prepared as flat mounts between sheets of Saran film, and the cornea-Saran sandwich placed be-

*This paper, illustrated with slides, was the first of three articles presented at a meeting of the Section on April 13, 1959. It was supported by Research Grant B492 (C-C4) from the National Institute of Neurological Diseases and Blindness, Public Health Service, Bethesda, Md.

tween 2 Eastman Kodak radioautographic plates. Radioautographs obtained in this fashion showed that incorporation of sulfate was homogeneous throughout the normal cornea from limbus to the center, and that the right and left eyes of an animal receiving sulfate parenterally were the same. Groups of at least 5 rats were used in each experiment, and in each animal 1 eye was intact. The corneal epithelium was removed with a small dry cotton swab while the rats were under light ether and local anesthesia. Endothelium was scraped with a narrow spatula, inserted into the anterior chamber through a transcleral incision.

Results

When the epithelium had been removed from one eye, the incorporation of sulfate in the stroma was found to be far less than in the intact eye. If the corneal epithelium were removed from portions of the cornea and left intact in others, radioautographs showed that the corneal stroma underlying the intact epithelium utilized the sulfate in synthesis of organic substances at a normal rate. For example, if a limbal zone of epithelium entirely around the circumference of the cornea was removed, leaving an intact central island of epithelium, the central corneal connective tissue took up sulfate that had been injected parenterally and incorporated it, presumably, in mucopolysacchardies. If the center of the cornea was abraded and the peripheral zone left intact, such synthesis occurred at the periphery under the epithelium. When abrasions were made some time prior to the injection of S^{35} sulfate, incorporation of the sulfate took place under the original intact epithelium and, to a lesser degree, under the thin, newly regenerated epithelium and at a still lesser rate in the as-yet exposed corneal stroma. Removal of Descemet's endothelium on the posterior surface was also found to inhibit the synthesis of sulfated corneal compounds. Therefore, there appears to be a synergistic relationship between the corneal connective tissue and both its anterior epithelium and the posterior Descemet's endothelium.

Discussion

The above data are interpreted as showing that, in the corneal connective tissues, synthesis of some ground substances is accomplished through joint or synergistic action of the epithelial covering and the connective tissue itself. Possibly the epithelial cells are a source of energy or of precursors necessary to the synthesis of chondroitin sulfate and/or keratosulfate.

It is interesting to consider the possible interdependent relationship of connective tissue and epithelia elsewhere in the body, and the metabolism of connective tissues that do not possess a direct relation to epithelial cells such as tendons or sclera.

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II. THE ACTIVE TRANSPORT OF SODIUM ACROSS THE CORNEAL EPITHELIUM IN THE RABBIT*

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It is generally believed that the normal cornea has a tendency to swell and lose transparency *in vivo*, and that this tendency is countered by the metabolic activity of the corneal epithelium or endothelium or both.[1-10] The active transport of an ion, such as sodium, out of the stroma across one of these limiting cellular layers could provide the necessary mechanism for maintaining the cornea in its normal unswollen state.[11-14] The purpose of the present work was to discover whether active transport of sodium actually occurred across the corneal epithelium.

Materials and Methods

Large adult rabbits were killed with intravenous nembutal, and the anterior segment of one eye was excised 2 mm. posterior to the limbus within 1 min. of death. Immediately afterward the lens and iris were dissected away and the cornea was clamped between 2 Lucite chambers specially designed to prevent the cornea from slipping and injuring the epithelium or endothelium. The area of the cornea separating the 2 chambers was 1.5 cm^2. A removable Lucite plug fitted into each chamber reduced its volume to approximately 0.5 cc.; these plugs were fitted with a ring of inflow channels and a single outflow channel so that fluid similar in composition to aqueous humor[7] could be circulated over both surfaces of the cornea.

Separate motor-driven syringes were connected to the inflow channels through lengths of plastic tubing. In each tube was inserted a T-piece in the side arm of which was a silver-silver chloride electrode embedded in 3 per cent agar. The outflow from each chamber passed through polyethylene tubing, the ends of which dipped into beakers of saturated KCl solution. The outflow tube from the chamber adjacent to the endothelium was placed 20 cm. above the other, so that the cornea was inflated by approximately its normal pressure. When samples were required, the outflow was collected in small test tubes at the appropriate level. The plastic clamp containing the cornea was supported in an oil bath at 37° C.

To measure the electric potential difference across the cornea, each outflow tube was immersed in its beaker of KCl, and these were connected by means of calomel electrodes to an electrometer.

*This paper, illustrated with slides, was the second of three articles presented at a meeting of the Section of Biological and Medical Sciences on April 13, 1959. The work described in this article, begun in the laboratory of David M. Maurice at the Institute of Ophthalmology, London, England, was supported in part by a "Fight for Sight" award of the National Council to Combat Blindness, Inc., New York, N. Y.

The electric resistance of the cornea was estimated at intervals by passing a small direct current through it and a 10,000-ohm resistance in series, and comparing the voltages developed across them. The current was passed through the cornea by means of the reversible electrodes inserted in the inflow tubes, and the potential difference generated across the cornea was measured across the outflow tubes. FIGURE 1 is a schematic representation of the experimental method.

In some experiments the Lucite clamp was withdrawn from the oil bath and the corneal thickness was measured optically by means of a corneal pachometer, as described by Maurice and Giardinni.[15]

The ion flux was measured by adding carrier-free sodium^{24} to the solution in one of the syringes and carrier-free sodium^{22} to the solution in the other. The rate of flow in each syringe was 5 ml./hr. and the steady state was achieved on each side in 30 min. Samples were taken from both sides of the cornea at intervals throughout an experiment, and the radioactivity was measured, using a standard end-window counter. By using an aluminum filter that allowed small amounts of sodium^{24} to be counted in the presence of sodium^{22} and by taking advantage of the large difference in the half-lives of these two isotopes, it was possible to calculate the separate flux of each isotope of sodium.

Results

(1) Optical measurements of corneal thickness revealed no significant difference between the corneae of living rabbits and the same corneae mounted in the clamp 10 min. later. Corneae clamped *in vitro* were able to maintain almost normal thickness (0.43 mm.) for 8 hours at 37° C. When these corneae were cooled to 4° C. they increased in thickness and, on subsequent warming to 37° C., they become thinner.

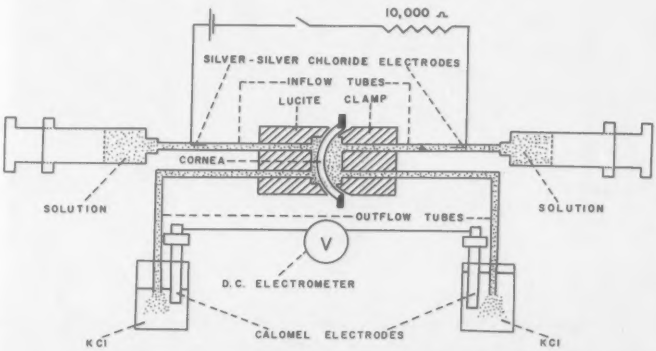

FIGURE 1. Schematic representation of the method of perfusing corneae and making electric measurements. Potential difference is measured across the outflow tubes. A known current passes through the cornea via the inflow tubes, and the change in potential is a measure of corneal resistance.

(2) The corneal preparations differed considerably in electric resistance and, for a given preparation, the resistance varied with time, usually increasing for the first hour and then remaining constant or slowly falling. In 19 experiments the range of peak resistances was from 2000 to 5000 ohms. When the epithelium was scraped off, this resistance immediately fell to below 50 ohms.

(3) Measurements of the electric potential across the corneal preparation showed that the aqueous-humor side of the cornea was always positive with respect to the tear-fluid side. Usually it took 1 to 2 hours to develop maximum values, which it then maintained with small fluctuations for 6 to 8 hours. In 19 experiments the range of peak potential difference was 15 to 42 millivolts. This potential disappeared instantly when the epithelium was removed, but no immediate change was noted on removing the endothelium.

(4) In some experiments the influx and outflux of sodium were measured simultaneously when the electric potential difference across the epithelium was short-circuited by a known outside current. Under these conditions it was found that the influx of sodium across the epithelium was more than twice the outflux and that the net flux of sodium was equivalent to approximately 90 per cent of the neutralizing current. FIGURE 2 shows a typical experiment. The average values for 7 experiments are as follows: sodium influx, 12.6; sodium outflux, 5.0; net flux, 7.6; and neutralizing current, 8.3 (sodium flux units are equivalents/second $\times 10^{-11}$ and the unit of current is amperes $\times 10^{-6}$). When this experiment was repeated at 4° C. there was no difference between sodium influx and outflux.

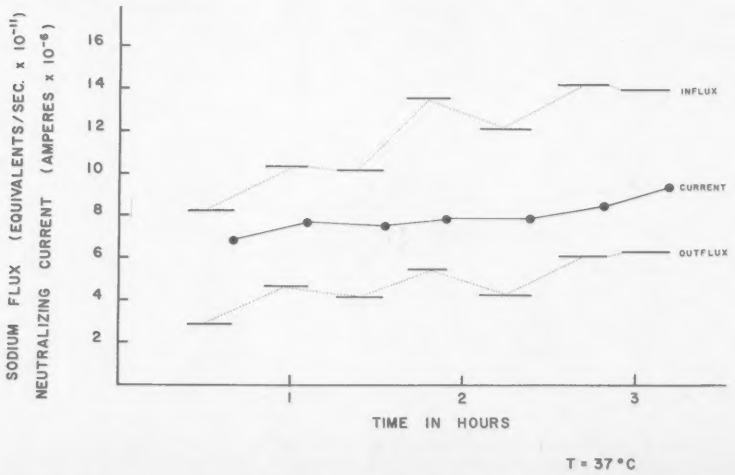

FIGURE 2. Simultaneous measurements of influx and outflux of sodium while the corneal electric potential was neutralized.

Discussion

The sodium fluxes measured in these experiments represent fluxes across the corneal epithelium alone because the resistance of the epithelium to the passage of sodium is approximately 70 times greater than the combined resistance of the corneal endothelium and stroma.[11] These experiments show that the corneal epithelium actively transports sodium ions from the tear-fluid side of the cornea into the stroma. The direction of this sodium pump – into the cornea, rather than out of it – is unexpected; and the significance of the active transport of sodium in the maintenance of normal corneal transparency is not clear.

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III. THE ROLE OF THE EPITHELIUM IN CORNEAL WOUND REPAIR*

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The healing of corneal and limbal incisions has been found to take place more rapidly in the anterior than in the posterior part of the wound.[1] The first synthesis of new connective tissues in such wounds also occurs beneath the epithelial plug.[2] The major metabolic activities of the cornea appear to take place in the epithelium; in fact, the stroma seems to be dependent upon the epithelium for some of its metabolism.[3,4] It was sought, therefore, to determine whether the presence of the epithelium on the anterior surface of the cornea influenced the healing of the stroma, as measured by the numbers of fibroblasts found at the wound edge at various time periods after injury.[5]

The rat cornea is particularly suitable for such studies, as it is thin enough to be studied microscopically without sectioning, and quantitative differential cell counts may be made through the entire thickness of the corneal stroma.

Previous studies on the pattern of normal stromal healing in standard penetrating incisions of rat corneas have shown that, during the first 24 postoperative hours, the corneal stromal cells undergo marked morphologic changes and become fibroblastlike in appearance.[6,7] The first notable morphologic changes in these corneal stromal cells are an increase in the number of nucleoli per nucleus and an increase in the size of the nucleoli. Microscopic examination of the wound edge at 4, 6, 12, and 24 hours after wounding shows the gradual transition of the corneal stromal cells into fibroblasts. The region of activation of the corneal stromal cells to fibroblasts is limited to a narrow border about 200 to 250 μ wide on each side of the wound edge.

Radioautographs of S^{35} uptake in wounded corneas indicate that it is precisely in this area of transformation of cells to fibroblasts that maximal fixation of S^{35} occurs.[8]

No fibroblasts were present in corneal incisions examined within the first 12 postoperative hours but, by the twenty-fourth hour, there were 35 fibroblasts per oil immersion field (970×) through all depths of the corneal stroma and, by 60 hours, 162 fibroblasts. At 120 hours the fibroblasts were so numerous that counts could no longer be made.

The presence of the epithelium is necessary in order that transformation of cells to fibroblasts may occur at the wound edge.[5] When the epithelium was removed daily from incised rat corneas, little or no healing as measured by counts of fibroblasts at the wound edge occurred up

*This paper, illustrated with slides, was the third of three articles presented at a meeting of the Section of Biological and Medical Sciences on April 13, 1959. The work described in this paper was supported by the Knapp Memorial Fund, New York, N.Y.

to 4 days, the longest time period studied. Only a few cells, equivalent to a 24-hour wound, had transformed to fibroblasts even after 4 days.

When the epithelium was removed only once, at the time of incision, the healing was delayed until about 48 hours after injury, the length of time required for the epithelium to grow from the limbus into the wound. After re-epithelialization occurred, the transformation of cells at the wound edge progressed at a rapid rate, although the number of transformed cells found at 96 hours was approximately 48 hours behind that of the controls.

The growth of epithelium over the denuded stroma caused a pronounced transformation of corneal stromal cells into fibroblastlike cells throughout the cornea, suggesting that a possible cause of the transformation of cells at the wound edge may be substances released by the actively growing epithelium at the wound edge.

Other evidence has also been found to show that the early responses of the corneal stromal cells to injury are triggered by reactions occurring in the epithelium. It has been observed previously that corneal stromal cells in normal corneas do not take up the vital dye neutral red.[7] However, within 12 hours after injury *all* the corneal stromal cells are activated to take up this dye in large quantities. The mechanism by which these activated corneal stromal cells actually take up the dye is unknown, but this phenomenon has provided a useful tool for detecting the influence of various chemicals on the early steps of wound healing.

A procedure was developed for studying quantitatively *in vitro* the activation of the corneal stromal cells to transport neutral red under controlled and reproducible conditions.[9]

The epithelium plays an essential role in the activation of the corneal stromal cells to transport the dye. If the epithelium is removed without trauma of any kind, the corneal stromal cells never become activated and never take up the dye. If the epithelium is left on and the trauma limited to that of cutting the cornea for placing it *in vitro*, the uptake of the dye begins during the fourth postoperative hour. However, if the epithelium is crushed with a swab, uptake of neutral red begins within 1 hour after injury.[9] This evidence indicates that the crushed epithelium liberates an unknown factor or factors that immediately cause the activation of the corneal stromal cells.

Proteolytic activity in the wounded cornea appears to be necessary for the activation of the corneal stromal cells to transport the dye.[9] Soybean trypsin inhibitor (STI) prevents the release of the activating factor(s) by the epithelium. If the epithelial cells are crushed, the factor(s) is (are) released directly, by-passing the phase of proteolytic activity, for STI is no longer inhibitory.

Trypsin was found to be an effective activator of the cells to transport neutral red.[9] Trypsin, however, also acts only in the presence of the epithelium, again indicating that proteolytic activity in the epithelial

cells liberates the factor(s) acting on the corneal stromal cells to stimulate them to transport neutral red.

Summary

The presence of the epithelium is necessary for the development of fibroblasts at the wound edge of central corneal wounds. The epithelium is the source of proteolytic enzyme activity, which releases a factor(s) leading to the activation of corneal stromal cells to transport the vital dye neutral red.

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ENGINEERING IN MEDICINE: DESIGN OF AN ARTIFICIAL KIDNEY*

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Nomenclature

Arabic

A	area, cm.^{2}
c	concentration, any consistent units
D	diffusion coefficient cm.^{2} – sec.$^{-1}$
h	flow-path height, cm.
k	individual coefficient, cm. – sec.$^{-1}$
K	over-all coefficient, cm. – sec.$^{-1}$
K'	constant in pressure drop equation, approximately 9.00 (10^{-5}) centipoise – mm. Hg^{-1} – sec.$^{-1}$
L	over-all flow-path length, cm.
N	mass transfer rate, mols – sec.$^{-1}$
P	pressure, mm. Hg
Q	flow rate, cm.^{3} – sec.$^{-1}$
Re	Reynolds' number, dimensionless
S	cross-sectional area of flow path perpendicular to direction of flow, cm.^{2}
v	velocity, cm. – sec.$^{-1}$
V	volume, cm.^{3}
w	width of flow path, cm.
z	point along the flow path, measured from entrance, cm.

Superscripts

0	at time zero

Subscripts

A	a unique value
B	blood or blood side
E	exterior fluid or exterior

*This paper, illustrated with slides, was presented at a meeting of the Division on April 17, 1959. The work described in this article was supported in part under contract DA-49-007-MD-707, by the Research and Development Division, Office of the Surgeon General, Department of the Army, Washington, D. C.

† Markle Scholar in Medical Science.

i	incoming
o	outgoing
m,B	at the membrane surface, blood side
m,E	at the membrane surface, exterior
max	maximum

Greek

Δ	difference operator
θ	time, seconds
μ	viscosity, centipoise

Superscript

θ	at time

Subscript

Σ	over-all

Any effort to develop a man-made device to replace the function of a living natural organ must begin with an understanding and definition of the specific function or functions to be replaced. The function of the human kidney is primarily homeostatic, that is, its function is to regulate the composition and volume of the body fluids as dictated by sensing devices, most of which are located elsewhere. This regulation is accomplished solely by effecting a net removal of solutes from the blood stream; important among these solutes are waste products from protein metabolism, water, and inorganic salts. When in certain kidney diseases these regulatory processes degenerate, the abnormal chemical state known as uremia develops. The artificial kidney is designed to replace or supplement the regulatory function of the natural kidney in such uremic states. Another special but not unusual problem sometimes attacked with the artificial kidney is the removal of ingested poisons that cannot be effectively handled even by a healthy kidney.

A primary problem with a kidney substitute is: How can one discriminate between materials to be removed and those to be retained? Important light is shed on this question by what we know of the natural kidney functions. The natural process takes place fundamentally in two steps: first, blood supplied to the kidney is filtered, the so-called "ultrafiltrate" normally consisting of water and all other molecules contained in the blood stream that are smaller than proteins, the energy source here being hydrostatic pressure; second, the filtrate is contacted with a membrane that (a) selectively reabsorbs most of the small molecules, such as water, glucose, and many salts that the body must conserve and (b) selectively secretes other molecules into the filtrate. The concentrated fluid left after this additional processing is passed off as urine.

In artificial kidneys, solute discrimination is either chemical or physical. No known, simple, chemical criterion serves to separate, as a group, all the chemicals that the normal kidney removes from all those it must retain. Therefore, artificial kidneys operating on a simple chemical principle can remove only a few specific solutes. A typical chemical process of this sort is ion exchange, sometimes employed clinically for the reduction of blood potassium levels.

Contrariwise, a physically based separation can be made to approach that of the living, healthy kidney. Broadly speaking, the physical process currently used in artificial kidneys is equivalent to that of the natural kidney: a group of molecules whose dimensions are relatively small are permitted to pass from the blood stream, through a membrane, into an exterior fluid, and a relationship is established between the small solutes in the exterior fluid and those in the blood, thereby limiting concentration changes in the blood. This equivalence in over-all function is not matched by identity of mechanism. Natural kidney function has been stated to be essentially a two-step process: filtration followed by selective reabsorption and secretion. The natural process is also endoergic, the free energy of the outgoing streams (concentrated urine and processed blood) being greater than that of the incoming blood. In the sense of the second law of thermodynamics, the body has used sources of energy independent of the fluids to effect an "uphill" separation.

On the other hand, the artificial function depends upon a single-step process, dialysis. Dialysis is the selective transport of solutes through a semipermeable membrane in the direction of and in proportion to a concentration gradient. This process operating in an artificial kidney causes the small solutes in blood to approach equilibrium with those in a large volume of exterior fluid. Since it involves an approach to equilibrium, the process must be exoergic, the free energy of transport being obtained from the fluid streams.

One may ask why a more direct imitation of natural function is not used. Two problems arise. The first is that "active" membranes such as that used by the kidney in reabsorption are not available. (Active membranes are distinguished from passive ones as those that can utilize energy from external sources to effect transport against a concentration gradient.) An active membrane suited to our purpose would not only have to accept a separate source of energy, but would be required to have a separately specified and externally variable transport rate for each of the many solutes involved. The second problem is that the control required for each of the solute-transport rates of such a membrane is not thoroughly understood even in principle, not to speak of practice. In contrast, the "passive" membrane process necessarily requires the solutes in the blood to approach a set of concentrations that is in equilibrium with the exterior fluid. This mechanism permits solute transport rates to be controlled through simple manipulation of exterior solute concentrations. Since no

practical method of synthesizing and controlling an artificial, broad-spectrum, active membrane is likely to be devised in the foreseeable future, size-restricted transport through passive membranes (dialysis) remains, at present, the best practical basis for supplementation of renal transport.

Many important engineering problems arise in connection with the design of a hemodialysis system. Of these we have primarily considered those that affect the transport process itself: membrane selection and dialyzer design. We report here only our work in the latter area.

The results of all membrane-transport studies, theoretical and experimental, may be expressed in terms of the coefficient k_m, defined by the equation

$$dN = k_m (C_{m,B} - C_{m,E})\, dA. \tag{1}$$

The quantity dN is the time rate at which the solute is transported across the differential membrane area, dA, when the concentration difference between the membrane surfaces is $(C_{m,B} - C_{m,E})$. The coefficient k_m is inherently subject to variation from solute to solute, is a function of the mean concentration of the solute under consideration, is a function of the concentrations of other solutes in the membrane, and varies widely from one membrane to another. Nevertheless, k_m frequently will not vary so much in a given apparatus under stated conditions that valuable results cannot be obtained from analyses based on its constancy. For simplicity, we shall consider only such cases here, although the extension to many common cases of coefficient variation follows easily.

The situation represented by EQUATION 1 may be pictured as in FIGURE 1. The concentrations $C_{m,B}$ and $C_{m,E}$ exist only in the infinitesimal volumes of fluid just touching the surface of the membrane. The concentrations in the bulk of the fluid streams flowing by dA will be different from the surface values. The bulk-average blood-side concentration, C_b, will be greater than $C_{m,B}$, and the bulk-average exterior-fluid concentration, C_E, will be less than $C_{m,E}$. The physical situation closely parallels that in a heat exchanger, where similar differences exist between bulk and wall temperatures. The analysis here is handled in a strictly analogous manner: EQUATION 1 is rewritten in terms of the bulk-average concentrations at dA:

$$dN = K_\Sigma (C_B - C_E)\, dA \tag{2}$$

It may be shown[1] that

$$K_\Sigma = \frac{1}{\frac{1}{k_m} + \frac{1}{k_B} + \frac{1}{k_E}} \tag{3}$$

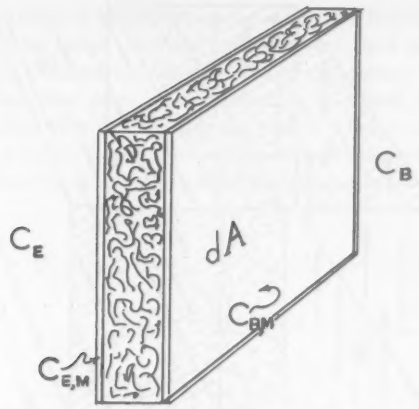

FIGURE 1. Differential section of membrane surface.

where the over-all coefficient, K_Σ, is necessarily less than k_m. The effect of the always finite and positive values of the "fluid-film coefficients," k_B and k_E, is thus to decrease the concentration difference across the membrane proper, thereby reducing the transport rate.

In clinical dialyzers that we have studied[2] fluid film coefficients have been low enough appreciably to reduce transport rates and, in one case, the process was more seriously affected by these than by the membrane coefficient. For this reason, EQUATION 3 takes on special significance, all the more so because biologists frequently use EQUATION 2 as if its proper coefficient were a function of membrane properties only, that is, as if K_Σ were k_m. Fortunately, both experimental and theoretical bases for prediction of k_B and K_E are available.[2] These coefficients depend, of course, on flow-path design and on flow rates, and we shall consider them in detail, later, in terms of specific cases.

If k_B, k_E, and k_m are known, the transport rate across any differential membrane area, dA, is established in terms of the adjacent bulk-fluid concentrations. The problem then becomes one of finding the distribution of concentration differences across the gross membrane area, A, and of finding the associated over-all transport rate.

It can be shown, for any membrane dA that is associated with a flow-path length, dl, as shown in FIGURE 2, that the rate of transport can be related to fluid velocities and rates of concentration change:

$$dN = v_B dS_B \frac{dC_B}{dl_B} = - v_E dS_E \frac{dC_E}{dl_E} \qquad (4)$$

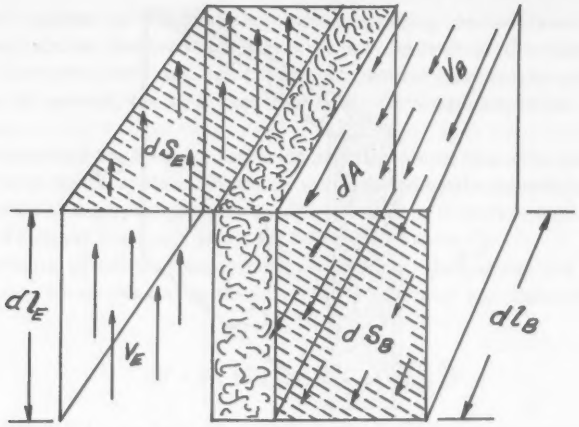

FIGURE 2. Fluid flow past the membrane surface.

where v is the fluid velocity and dS is the cross-sectional area of the flow path perpendicular to the direction of flow.

EQUATIONS 2 and 4 may be easily combined and integrated for many cases where the flow rates and $K_\sum$ do not vary significantly and where the parameters and boundary conditions are time-invariant.

At this point it may be helpful to illustrate the application of EQUATIONS 2 and 4 to the analysis of one artificial kidney in current use, in terms of the clinical circumstances in which it is used. FIGURE 3 shows the MacNeill-Collins dialyzer, a unit whose performance we recently studied.[3] Through the parallel, flattened tubes, which are made of cello-

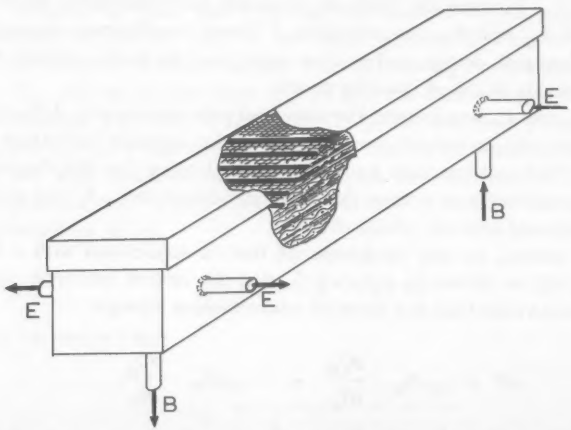

FIGURE 3. The MacNeill-Collins dialyzer showing blood (B) and exterior fluid (E) inlets and outlets.

phane, flows a stream of blood, typically withdrawn from the body through a tube placed in the radial artery of the lower arm, and returned to a vein in the upper arm. Around the outside of the cellophane tubes flows the exterior fluid supplied from and returned to a mixed, thermostatically controlled bath. The flow is cocurrent, so that in EQUATION 4 $dl_B = +dl_E$. Combining EQUATIONS 2 and 4 for this case, and assuming the reservoirs to be so large that the operation is essentially time-invariant, one obtains the result:

$$N = Q_B\,(C_{B,i} - C_{B,o}) = Q_E\,(C_{E,o} - C_{E,i})$$

$$= K_\Sigma A \frac{(C_{B,i} - C_{E,i}) - (C_{B,o} - C_{E,o})}{ln\left[\dfrac{C_{B,i} - C_{E,i}}{C_{B,o} - C_{E,o}}\right]} \qquad (5)$$

where Q refers to volumetric fluid flow rate (the integral of vdS in EQUATION 4, and the subscripts i and o refer, respectively, to incoming and outgoing fluid. For the MacNeill dialyzer the flow-path layout is approximately that of FIGURE 4*a*. In other dialyzers fluids may be contacted as if they were in a mixer, (4*b*) or, countercurrently, (4*c*) or, in more complicated ways, such as crosswise, (4*d*). Analogous solutions of value in dialyzer design have been worked out for heat transfer through these and other flow-path arrangements.[4,5]

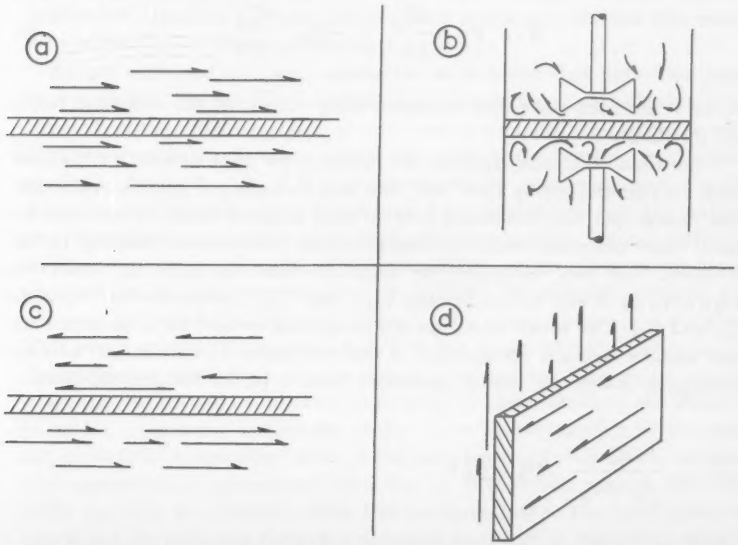

FIGURE 4. Four idealized flow-path arrangements (*a*) cocurrent, (*b*) mixed, (*c*) countercurrent, and (*d*) crosswise.

EQUATION 5 may be recast into another form:

$$\frac{N}{C_{B,i}} = \frac{Q_B \left[1 - \exp\left[-K_o A\left(\frac{1}{Q_B} + \frac{1}{Q_E}\right)\right]\right]}{1 + \frac{Q_B}{Q_E}} \tag{5a}$$

where the notation *exp* should be read "*e* to the [ ]." The term $N/C_{B,i}$ equals $Q_B\ (C_{B,i} - C_{B,o})/C_{B,i}$ and is the "dialysance" first defined and used by Wolf.[6] When, and only when, Q_E is much greater than Q_B does EQUATION 5*a* reduce to Renkin's equation:[7]

$$\frac{N}{C_{B,i}} = Q_B \left[1 - \exp[-K_\Sigma A/Q_B]\right] \tag{5b}$$

In all clinical applications of dialysis the process necessarily functions in the unsteady state, thus to some degree violating the steady-state assumption on which EQUATION 5 and the other, referenced solutions are based. Because the body, as well as the exterior fluid reservoir, has finite capacity, as the procedure goes on solute concentrations in both reservoirs approach equilibrium values for the system, the effects being related as in EQUATION 6, if both reservoirs may be assumed to be well mixed:

$$N = V_B \frac{dC_B}{d\theta} = -V_E \frac{dC_E}{d\theta} \tag{6}$$

where V includes the entire communicating volume of the indicated fluid, and θ is time.

If the fluid residence times in the dialyzer are each defined as dialyzer fluid volume divided by flow rate, one may calculate a system concentration change per unit residence time; if this value is found to be small for each fluid compared with all concentration differences existing in the dialyzer, one may calculate the unsteady-state behavior by combining EQUATIONS 5 and 6 and setting $C_{B,i}$ and $C_{D,i}$, respectively, equal to C_B and C_D. The result was first given by Wolf *et al.*[6] for a simpler case and without explicit recognition of the necessary limitation on the concentration change per unit of residence time. It is, for the present case:

$$C_B^{\theta} = \frac{V_E}{V_E + V_B} \left(C_B^0 - C_E^0\right)$$

$$\exp\left[\frac{1-\exp\left[-K_{\sum}A\left(\frac{1}{Q_B}+\frac{1}{Q_E}\right)\right]}{1+\frac{Q_B}{Q_E}}\left(\frac{1}{V_B}+\frac{1}{V_E}\right)\theta\right]$$

$$+\frac{V_B}{V_E+V_B}C_B^0+\frac{V_E}{V_E+V_B}C_E^0 \qquad (7)$$

where the superscripts refer to the time "θ" and "zero." For many clinical situations, this concentration change per unit of residence time is sufficiently small to justify the approach used in the derivation of EQUATION 7. A more serious error may be attributed to the implicit assumption that the body's inventory of solutes can be simulated by a well-mixed pool of concentration C_B equal to $C_{B,i}$.

Observed deviations from such a simple formula as 7 indicate that better assumptions would be either: (1) that some solute quantities are supplemented by conversion of an accumulated precursor during dialysis (that is, solute B, undergoing dialysis is being replaced by a shift in the equilibrium $A \rightleftharpoons B$); or (2) that finite times are required for tissue fluids and other solute reservoirs in the body to communicate with the blood.

Nevertheless, it appears that in principle we may obtain accurate expression for blood concentration changes in dialysis when values for $K_{\sum}$ (that is, for k_B, k_E, and k_m) can be obtained. Membrane transport studies leading to values of k_m have already been discussed, and we turn here to a consideration of factors affecting k_B and k_E.

Almost all blood dialyzers utilize the same basic flow path, that shown in FIGURE 5, for the blood stream. Such unanimity in path design arises because of the great emphasis placed upon a high surface-to-volume ratio. This flow path is, in many cases, a close approximation to the much-studied, idealized case of flow between infinite parallel plates. For this geometry and when the flow is laminar, heat transfer through the walls of the plate has been visualized as an eigenvalue problem,[8] and a method of solution has been proposed. After substitution of the appropriate dimensionless groups for mass transfer, we applied the proposed method, with minor modification, to the calculation of the curve shown in FIGURE 6. This curve relates the quantity $k_B h/D$ to the group zD/vh^2. The term D is the diffusion coefficient of the solute in question The curve applies when the asymptotic value predicted for k_m at large values of the abscissa is within an order of magnitude of $K_{\sum}$. Two characteristics of the curve are especially noteworthy: first, if the path length is very short, no blood-film resistance is encountered (that is, k_B is infinite); second, with long paths k_B falls to a limiting value that is equivalent to the coefficient one would find for diffusion through a stagnant fluid-film of thickness equal to one fourth of the parallel-plate spacing.

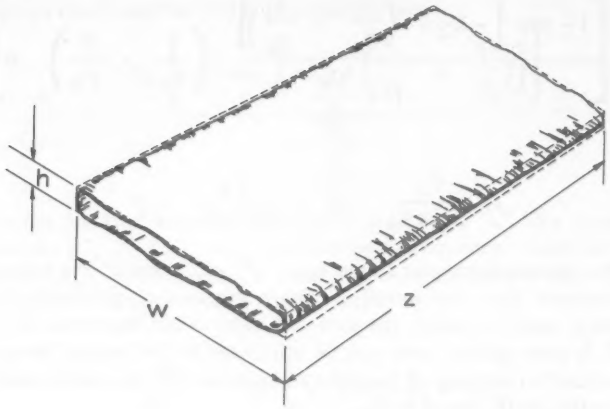

FIGURE 5. Common shape for path of blood flow.

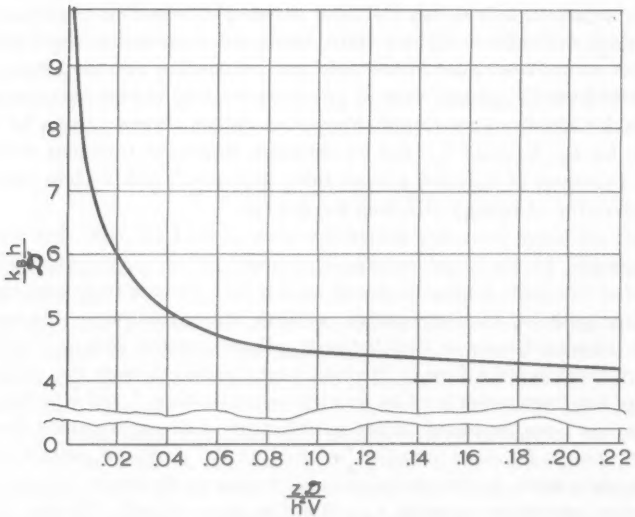

FIGURE 6. Theoretical relationship between k_B and operating variables.

While application of this formula is limited to cases in which the flow is laminar, almost all blood flows are made to take place well below the critical Reynolds number because turbulence has a destructive effect on the cellular elements in blood.

No such restriction on shear rate or turbulence applies to the exterior

fluid. Here one should seek to promote turbulent flow in order to increase the exterior film coefficient.

No uniformity exists in design of the exterior path such as that found for the blood path. Some blood dialyzers interpose screening between blood paths in the manner shown in FIGURE 7*a* and in FIGURE 3. However, this and similar woven materials may be far from desirable, since they contact too much of the membrane surface and do not promote turbulence as effectively as might be desired.

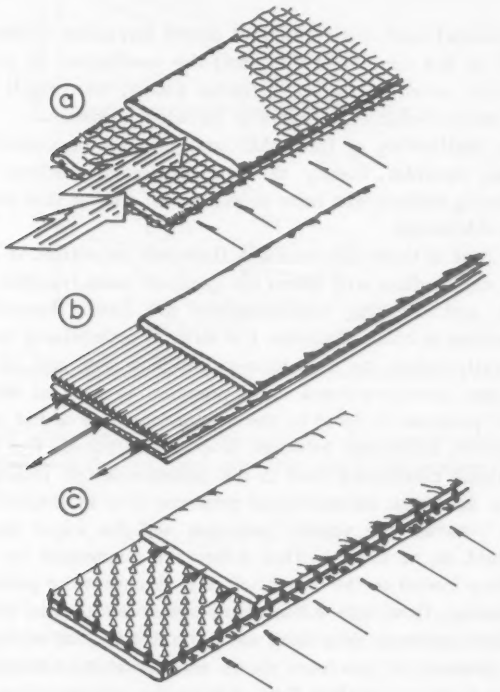

FIGURE 7. Three membrane supports (*a*) screen, (*b*) grooves, (*c*) cones.

The dialyzer of Skeggs and Leonards[9] used a grooved flow path for dialyzing solution (FIGURE 7*b*); while this design provides the necessary support to maintain the desired membrane spacing and gives a surface over which exterior fluid can pass, it does not promote turbulence.

We have lately tested the supporting arrangement shown in FIGURE 7*c*; this support is designed to provide minimum contact with the membrane

and to promote well-developed turbulence.[10] Tests made under operating conditions indicate that this geometrical arrangement raises k_E to values such that only k_B and k_m control the transport rate.

When a regularly repeating and well-defined geometrical arrangement, such as that obtained with these cones, is considered, one may extend experimental data reliably through the use of dimensional similitude:

$$\frac{k_{E,1}\, h_1}{D_1} \quad (Re_A) = \frac{k_{E,2}\, h_2}{D_2} \quad (Re_A) \tag{8}$$

Our experimental work indicates that above Reynolds numbers of 100 to 200 (based on the cone-base diameter) the coefficient is proportional to fluid velocity raised to the eight-tenths power; this result is in accord with many other coefficient studies in turbulent systems.

With the availability of this additional information concerning k_B and k_E, one may consider, finally, the over-all design problem. Once a suitable supporting medium has been selected, the crux of this design problem lies in two decisions.

(1) The first of these decisions is flow-path selection. It can easily be shown that counterflow will effect the greatest mass transfer when $K_\sum$, A, flow rates, and incoming concentrations are fixed. However, a special situation arises in blood dialysis. For ease in maintaining sterility, blood flow is usually inside the membrane-walled flow path and, of course, inner pressure must always exceed outer pressure to prevent collapse of the path. Outlet pressure is fixed by the venous pressure of the patient unless an undesirable, additional pressure drop is interposed. For a counterflow situation these conditions lead to the pressure-length relationship shown in FIGURE 8*a* where exterior-fluid pressure drop is limited either to the difference between the venous pressure and the vapor pressure of the exterior fluid or, at best, to this difference augmented by an additional pressure drop forced on the blood before it re-enters the patient.

In cocurrent flow, the situation is relieved to the extent that the exterior fluid pressure drop need not be added to that of the blood (FIGURE 8*b*). However, it has been shown above that it is desirable to propel the exterior fluid in turbulent flow, making the pressure-drop restriction of any long flow path inconvenient. Therefore, crosswise flow paths are often used, giving rise to pressure profiles such as that of FIGURE 8*c*. With the correspondingly short exterior fluid flow paths, high-pressure gradients and high velocities can be used. Two benefits result: (*a*) the resulting value of k_E is high; and (*b*) with the high flow rate so obtained, the forced reduction of efficiency in crossflow below that obtained in counterflow can be made negligible.

(2) The second critical design decision is selection of the blood channel path dimensions. Several constraints influence this selection.

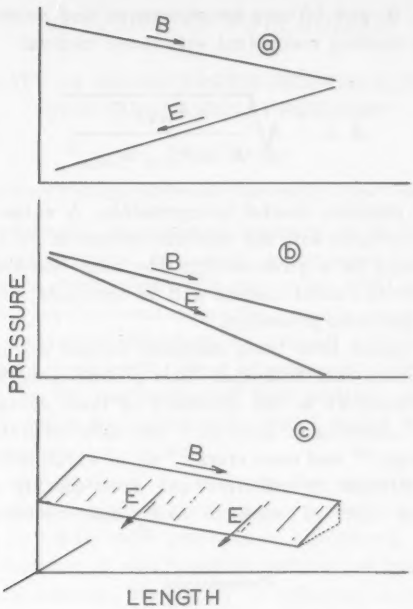

FIGURE 8. Pressure-length plots for (*a*) countercurrent flow, (*b*) cocurrent flow, and (*c*) crossflow.

First, area and plate spacing are related by a filling-volume restriction. When both surfaces of the path are used this may be expressed as:

$$A = 2Lw = \frac{2V_{max}}{\dot{n}} \tag{9}$$

where L is the length of a surface of width w. Second, a maximum pressure drop is usually specified; this may be related to path dimensions, fluid properties, and flow rate:[11]

$$L = \frac{K'\Delta P_{max}\dot{n}^3 w}{\mu Q} \tag{10}$$

where ΔP is the pressure drop, μ is the viscosity, and K' is a dimensional constant. Third, a practical constraint on w is imposed. When path widths are made too great, channeling develops and, when a number of paths in parallel are used, the total practical number is limited by the complexity of the connection technique. As a consequence, a total maximum path width, w_{max}, appears to prevail.

EQUATIONS 8, 9, and 10 may be rearranged and combined to give a value for the plate spacing consistent with these maxima:

$$h = \sqrt[4]{\frac{\mu V_{max} Q}{K' \Delta P_{max} w_{max}^2}} \tag{11}$$

EQUATION 11 requires careful interpretation. A value of h is calculated that, when combined with the maximum values of V, ΔP, and w, will yield a single design for a given design flow rate. However, many different values of these so-called maxima will be specified, depending on the clinical goal and preferred procedure.

Most artificial organs have been designed without cognizance of many engineering principles that determine their performance. While these devices are true monuments to the ingenuity of their designers, it seems clear that future homeostatic devices – not only artificial kidneys, but also man-made lungs,[12] and even uteri,[13] all of which are under development – will be brought to effective use more quickly and more fully through the joint use of medical skill and chemical engineering technology.

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THE QUALITY OF GROUP VERSUS INDIVIDUAL SOLUTION OF HUMAN RELATIONS PROBLEMS*

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In spite of equivocal experimental evidence, it is frequently assumed that the decisions of groups, in general, are superior to those made by individuals. A review of the literature (Lorge *et al.*, 1958), however, indicates that experimental studies most frequently cited in support of group superiority are not conclusive; therefore, an over-all generalization of either individual or group superiority cannot be proposed at the present time. As an initial step in the exploration of this problem, research has been focused upon defining conditions under which either individual or group decisions are superior.

This study was designed to estimate the superiority of individual versus *ad hoc* group decisions about complex, realistic problems when it was necessary to handle such problems in a relatively short time. In the present study, therefore, it was hypothesized that, within the experimental time limit of fifty minutes, the quality of individual decisions about realistic, complex problems would be superior to the quality of decisions made by groups about the same problem.

The subjects of this study were 177 Air Force officers, whose military rank ranged from captain through colonel and who were enrolled at the Air University. The study was conducted during their first week there, before they received instruction either in group dynamics or in problem-solving techniques.

In general, the more complex the problem for decision, the more difficult it is to find adequate means for the appraisal of its solutions. At one extreme are problems for which there is a known or knowable solution. These are designated as "eureka" problems. At the other extreme are problems so complex that it would be impossible to ascertain the complete efficacy of the solutions. Such complex problems are designated as "rational decision" problems.

The problem about which the subjects were to write a decision involved raising the deteriorated morale of airmen stationed at an imaginary Air Force base in the United States. The situation was completely described

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with enough specific details for an actionable solution. In summary, the problem involved an Air Force base isolated in desert country; the base facilities were inadequate to care for a recent increase of activities; the A.W.O.L. and V.D. rates were unusually high; and the social and recreational facilities of the nearest town seemed to be limited to gambling, drinking, and prostitution.

The statement of the problem was presented with the following instructions: "State a plan of action to solve this problem. Your plan should be complete; that is, it should cover all aspects of the problem. Your plan should also be specific; that is, each step or action should be specified concretely."

The decisions were written during 2 consecutive 50-minute periods. During the first period, 75 subjects, randomly selected from the experimental population, wrote individual decisions about the problem. These solutions shall be referred to as Individual First decisions. Another 102 subjects, randomly selected, were organized for the first period into 17 groups of 6 members to write a decision as a group about the same problem. These solutions will be referred to as Group First decisions.

For the second period, the subjects who had written Individual First decisions were organized into 12 groups to write a decision as a group about the *same* problem they had solved as individuals. These solutions are termed Group Second decisions. From those who had written Group First decisions 45 were asked to write decisions as individuals about the same problem during the second period, and these solutions are called Individual Second decisions. In other words, the experimental design involved 2 consecutive 50-minute periods in which approximately one half of the experimental population followed individual, then group solution, while the other half followed group, then individual, solution.

The quality of the decisions was estimated by the method of quality point scores (Lorge *et al.*, 1953). Essentially, this technique of evaluating rational decision involves, first, a content analysis of points or ideas in a decision; second, the assignment of a numerical value for the judged quality of each point. The sum of numerical scores or the quality values for the points in a decision give the quality score for the total decision.

The "rational decision" solutions written for the Wilco Air Force's problem showed an unusual range. Experts could recognize that many solutions tended to treat only a specific symptom of the problem; on the other hand, experts appreciated the nicety of the perceptions in some of the solutions. These, indeed, indicated not only the diagnosis of the many factors in the problem, but also an anticipation of the consequences of the several aspects of the action plan. The extraordinary diversity among the solutions suggested that it would be possible to identify the factors diagnosed in the plans for alleviation of the situation. The technique, essentially, requires an analysis of the decisions by broad areas and factors and by specific courses of action.

The steps involved: first, making a representative sampling from all decisions collected; second, developing a content analysis of each positive point or idea regardless of its location in each written decision; third, arranging in a master scheme the broad areas in which each specific point could be located; and fourth, assigning numerical credits to each broad area and, within it, to each specific point.

For instance, for Wilco Air Force problem, 300 solutions were selected at random. These were content-analyzed into broad groups such as: regulations and discipline; leadership and training; morale and military customs; problem-solving procedures; housing and facilities; civilian-military relations; passes, leave, and work schedules; and recreation.

Each separate point under each broad category was identified separately by a code number, for example, "communicate disciplinary policy to personnel" as point 122, or "organize meetings and/or committees of airmen to work on problems to formulate policy" as point 411.

The content analysis based on the reading of 300 decisions encompassed more than 95 per cent of the points subsequently found in a second random sample of 200 more decisions. The summary of the different points and ideas found in the 500 decisions constituted the basis for the subsequent quantification of the quality score.

Four expert judges, after reading the problem, assigned numerical credits among the categories and to each point within a category under the constraint that the total sum for all credits would equal 100. The score for each point was the average of the values by the 4 independent judges.

Each decision, then, could be coded according to the content analysis scheme. The sum of the point values for any decision could be considered as the total quality score. Such a coding and scoring procedure, of course, allows, in addition, a frequency count of each specific point made by individuals or by groups, as well as a separate count of the number of broad areas in which such points are made. It cannot be expected that any one individual or group will make *all* the points in the complete master key. As a matter of fact, the average score before instruction is about 20, with a standard deviation of about 7.

There is no practical way to validate the quality score for the solutions to a problem as complex as Wilco Air Force Base. Try-out of each suggested decision is neither possible nor feasible. At second best, one can estimate whether the quality score does correlate with the judgments of independent experts about the over-all goodness of the decisions.

To test this, the relation between the rank-order of 50 decisions for over-all goodness and the quality scores was estimated. Six competent judges, independent of those used in establishing the rating system, arranged the decisions in order from best to worst, a process that took each judge about 4 hours. The average intercorrelation among the 6 judges was 0.74, so that the rank corresponding to the sums of judges' ranks has an

estimated reliability of 0.94. The correlation between the rank based on the sums and the quality score was 0.82.

In passing, it may be stated that the reliability of coding the solutions is extraordinarily high. Two independent content analysts analyzed the 50 decisions for points. The correlation between the 2 analysts for the quality score was 0.97, without significant difference between the mean quality scores or the standard deviations.

The technique of content analysis can be done objectively, reliably, and quickly. The scores are sufficiently sensitive to allow the measurement of the effects of instruction in problem-solving and in group dynamics, and of the differences between the decisions of individuals and groups.

The advantage of the content analysis is that it allows not only the designation of the kinds of points made by individuals and by groups, but also serves to suggest to teachers the kinds of points that are often, and the kinds that are rarely, proposed. In a sense, a content analysis of several hundred decisions is a summation of the best of many minds. It tends to codify all the possible positive points for handling a problem situation.

Against the panorama of such ideas, every specific decision, whether of an individual or of a group, can be appraised. Not only does the content-analysis scheme allow for evaluation of each such decision; it also gives a basis for making a diagnosis of faults and errors in problem solving. For instance, it allows the recognition that the solver concentrated most of his attention on a single factor and its alleviation; or again, that some solvers attack a symptom without considering its cause; or again, that a solver made a plan without anticipating the new difficulties it would entail.

Comparing only the decisions after the first period of 50 minutes, the average quality score for Individual First decisions is 18.6; for Group First decisions it is 13.1. The average Individual First decision is significantly superior to the average Group First decision.

For the second period, roles were reversed; the average quality score for Individual Second decisions is 22.1; for Group Second decisions it is 19.8. The difference for the second period between these two averages is *not* statistically significant.

It was possible to compare decisions made by the same subjects as individuals and in groups. Individual Second and Group First decisions were written by the same subjects; first in groups and then individually. The average of Individual Second decisions was significantly superior to average of the Group First decisions. Conversely, however, there is no significant difference between the quality of Individual First and Group Second decisions written by the same subjects. While the average of individual decisions written after a group meeting is superior to the average of group decisions made by these same individuals, there is no significant difference between the average of individual decisions written during the first period and the average of the group decisions written by the same sub-

jects during the second period. Individuals who write decisions after meeting in groups with this problem make decisions superior to those of the groups in which they were members. If individual decisions are written first, however, the groups do not make decisions superior to those of the individuals who comprise the group.

With another group of Air Force officers, under similar circumstances, the same general results were obtained with another problem involving the maintenance of the efficiency of an isolated Air Force base in the Arctic.

The differences here reported are based on decisions made by subjects relatively naive in group interaction techniques. Since the groups were *ad hoc* and without tradition and since the time allowed for the written decision was very short, the results must be considered as suggestive. Furthermore, only one aspect of deciding has been studied, that is, its quality of planning.

Nevertheless, the data are incontrovertible in showing for individuals and *ad hoc* groups, relatively naive in group interaction and problem-solving techniques, deciding realistic, complex problems in a short period of time, that the average quality of the individual decisions will be superior to the quality of the average group decisions. After fifty minutes of experience with the same problem, however, there is no significant difference between the quality of the average individual and group decision. If members of a group write individual decisions after making a group decision about the same problem, in general those individual decisions of the group members are superior to the initial group decision. On the other hand, if subjects first write individual decisions and then meet to write a group decision, in general, despite the additional time, these group decisions are not superior to those written initially by the individual group members.

In the "rational decision" solutions, groups are more critical of the ideas and suggestions of their fellow-members. The result, however, with this kind of problem tends to lead to a reduction in the number of good ideas actually written down. This does not mean that good ideas were not introduced into the group deliberation. As a matter of fact, in process observation and in controlled studies, the group fails to specify in its report at least two thirds of the good ideas produced within the group. The individual, however, in his less critical behavior does record a variety of suggestions related to different aspects of the complex problem, that is, the individual tends to record ideas over the full range of the factors in the problem. In complex problems with a wide potential range of ideas and actions, the tendency within the group toward critical review has the effect of constraining the area in which ideas get recorded, salvaging just about one third of the ideas contributed by the group. These ideas, in general, are the more important.

TABLE 1

THE AVERAGE QUALITY OF DECISIONS BY INDIVIDUALS AND BY GROUPS IN TWO SUCCESSIVE SESSIONS: FOR WILCO AIR FORCE BASE PROBLEM

Decisions by	First period N	Average	s
Individuals	75	18.6	6.8
Groups	17	13.1	6.5
Decisions by	**Second period**		
(after having discussed and decided problem in the previous period)			
Individuals	56	22.1	7.6
Groups	12	19.8	6.1

For X-weather squadron problem

Decisions by	First period N	Average	s
Individuals	44	17.3	5.5
Groups	18	12.9	3.6
Decisions by	**Second period**		
Individuals	49	21.5	5.8
Groups	9	18.1	4.2

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DIVISION OF INSTRUMENTATION

QUANTITATIVE ELECTRONIC TECHNIQUES IN OCULAR MOTILITY*

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The mechanisms subserving ocular movement have been investigated by physiologists and ophthalmologists for decades. Many of the classic dicta of neurophysiology were established through experimental observation of ocular movements and the application of optical, electronic, or mechanical recording techniques. Optical methods have the greatest precision for eye movement, but tell nothing of the innervation to the ocular muscles. The same defect is true of mechanical approaches and of the technique of electro-oculography. The latter consists of the recording of a DC potential of the eye by means of surface electrodes placed on the skin at the outer and inner canthi of the eyes. The amplified DC potential varies in accordance with the direction and speed of ocular movement, providing an objective record of such movements. The generator of this potential lies in the retina; consequently, the integrity of the retina is required for its demonstration.

Ocular electromyography provides a new approach to the analysis of ocular movement. In this technique fine needle electrodes are inserted subconjunctivally into the extraocular muscles and the potentials generated by the innervated muscle fibers are recorded. It should be noted that it is not the nerve impulse, but the muscle impulse, that constitutes the electromyogram.

Electromyographic techniques have long been employed in the study of peripheral muscular disturbances and kinesiology. In the last four or five years intensive investigations have been carried out in the application of this technique to human extraocular muscles. The contributions of these investigations have related especially to basic physiology. In addition, a new diagnostic approach to ocular motor disturbances, leading to new insights into the mechanisms of oculomotor palsies and strabismus or crossed eyes, has been evolved. It has made available a most sensitive test for disturbance of the motor end plate in the disease entity of myasthenia gravis. It has provided a truly innervational approach to the analysis of the various types of eye movement, such as the vergences and following or pursuit movements.

*This paper, illustrated with slides and motion pictures, was presented at a joint meeting of the Division and the New York Section, Professional Group on Medical Electronics, on April 21, 1959.

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Such data are of considerable importance in the evaluation of human oculomotor performance in stress situations such as confront the military.

The classic role of electromyography has been essentially qualitative. That is, it answers the question, is the recorded electric pattern normal or abnormal? The problem of ocular electromyography, however, is both qualitative and quantitative. Kinesiology, the study of movement, implies a large quantitative factor. For the evaluation of the energy level of ocular muscle activity, well-known electronic techniques have received a new application.

Integration of the electric signal provides a clearer index to activity of muscle than can be readily obtained by inspection of the signal itself. Differentiation techniques constitute another type of read-out of electric activity in which both digital and analogue data can be obtained. The combination of integration and differentiation provides a calculus of muscle activity.[1,2] These studies have led to new concepts of the mechanisms whereby the brain controls the movement of the eyes through innervation of the extraocular muscles.

The qualitative aspects of ocular electromyography may be summarized as follows:

The characteristic electric patterns of myopathy, lower motor neuron, and end-plate disease are similar in both peripheral skeletal and extraocular muscle. Differences are in degree and not in kind, thus demonstrating a fundamental similarity of both types of muscle. Although extraocular muscle has anatomical and pharmacological differences from peripheral skeletal muscle, these are mainly quantitative and not qualitative. Furthermore, the data of quantitative techniques demonstrate that the extraocular muscles behave physiologically in a manner quite analogous to that of peripheral skeletal muscle.

The combination of electromyography with strain-gauge study of the extraocular muscles in animals has clearly illustrated this principle. Strain-gauge techniques adapted to human extraocular muscles also support this concept.

Integration techniques may be of many types. A common method is to feed the signal into a capacitor that charges up and is then discharged in one of several ways. The capacitor may discharge at regular intervals selected through varying time constants. In this method the integral is expressed as an amplitude variation. I have employed such a circuit extensively. The circuit may be summarized as follows: the signal feeds a variable-gain amplifier through selectable time constants. Two stages of capacity-coupled amplifiers feed a cathode follower. A single-ended signal is converted to a balanced signal that is fed to a full-wave rectifier that converts the potentials to DC pulses. These are stored in a Miller integrator with a neon overload indicator to signal saturation. The capacitor is discharged at selected time intervals, such as one,

three, or ten times per second. On discharge, the integrator returns to zero or ground amplitude. Thus, the amplitude rise is proportional to the integral with adequate linearity. The height of the discharge is the desired integral.

Another method of integration employs a fixed-amplitude charge level of the capacitor. Upon achieving this level a pulse is generated. The integral is then expressed by the number of pulses generated. Such a frequency display usually requires an external counter. Another method employs full-wave rectification of the signal with application of the envelope to an amplitude-sensitive multivibrator.[4] Again, the integral is expressed as a frequency display. Another type of integrator, actually an average-amplitude indicator, has been used by myself and by other investigators.[3] The integrator stores impulses in a capacitor that continuously discharges through a resistor. Hence, the integral follows the activity of the signal with great faithfulness, depending on the time constant selected. This technique requires calibration coordinates.

Differentiation. For simplicity of analysis a frequency display of activity has much to commend it.[2] A differentiating circuit has been employed to convert the signal to a population of pulses. These are fed into a pulse-counting device and printed out automatically. Both digital and analogue outputs are available. Although a pure frequency output is not a true representation of the energy level, it nevertheless faithfully mirrors the state of muscle tension, as shown by numerous authors. There is some question whether linearity between electric integral and tension under isotonic conditions occurs, although there does appear to be a linear relation under isometric conditions. In the circuitry employed the signal is fed to an amplifier and is then transmitted through a cathode follower to the differentiating network. A choice of time constants allows differentiation of signals of different frequency. Each change of slope in the signal is represented by a spike in the differential. The intrinsically high frequency characteristic of extraocular motor units enables one to sort them out readily from any form of low-frequency interference. Care is necessary to avoid differentiating noise that gives a very hairy trace. Controls are provided to attenuate the signal and noise level. Moreover, the leading or trailing edge of the signal may be selected as positive or negative. A diode permits the removal of either positive or negative half of the differential. Since the counters operate on only one polarity, this permits electric counting and aids in the visual interpretation. An automatic printing unit enables a rapid record of the digital data to be displayed. Furthermore, an analogue output permits a potentiometric or galvanometric record to be obtained along with the digital record. The use of a tape-recording system allows one to apply various methods of analysis at leisure.

Experience thus far with integrating and differentiating techniques indicates that they are valuable adjuncts to the analysis of activity

of extraocular muscle and have an important role to play in both diagnostic and kinesiologic studies. Additional electronic experimentation and application of engineering principles may lead to improved methods of data handling in biological problems, as has been demonstrated for the extraocular muscles. This should facilitate more automatic diagnoses and permit a more objective evaluation of motility.

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DIVISION OF MYCOLOGY

I. PATHOGENESIS IN THE *FUSARIUM* WILT DISEASES*

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Introduction

While invading the host, *Fusarium oxysporum* produces both enzymes and vivotoxins that alter the host, and it, in turn, interacts with these substances. The result is a sequence of characteristic symptoms.

Infection of the plant usually occurs through the roots, the pathogen being soil-borne. Once *Fusarium* has entered the roots, it penetrates to the xylem. Once there, it lives in xylem tissue exclusively until the plant dies. In the xylem the fungus grows from the roots into the stem and finally into petioles of leaves, causing severe dysfunction of tissues. Finally the fungus sporulates on the surface of the dead plant and the spores then return to the soil until they infect another plant.

The *Fusarium* wilt diseases have a characteristic syndrome. Within a few hours of infection there is a clearing of the ultimate veins of leaflets. Shortly thereafter the leaves bend downward without wilting. A few days later the bottom leaves gradually wilt and turn yellow. Younger leaves then become involved until the entire plant is affected. As wilting becomes severe, leaves wither. While these symptoms develop, the vascular bundles in stem and petiole turn brown.

The problem before us is to account for these symptoms in biochemical terms. A number of different plans respond in a strikingly similar way to invasion by several wilt-producing fungi. Surely, similar biochemical mechanisms are involved in these cases.

The Epinastic Phase

Epinasty apparently results from the production of ethylene by *Fusarium* as it grows in the host. Ethylene is known to produce epinasty in plants at very low concentrations. Dimond and Waggoner (1953) have shown that *F. oxysporum* f. *lycopersici* produces ethylene in culture. They also demonstrated that *Fusarium*-infected tomato plants give off ethylene, whereas young healthy plants do not. Thus, a diseased plant, confined under a bell jar with a healthy plant, induces epinasty in the healthy one. Evidently, the ethylene produced by the fungus is transferred through the water-conducting system of the plant and induces epinasty in growing tissues.

*This paper, illustrated with slides, was the first of two articles presented at a meeting of the Division on April 24, 1959.

Wilting of Leaves

In *Fusarium*-infected plants, leaves wilt progressively up the stem over a period of several days. Scheffer and Walker (1953) demonstrated the presence of plugs in the water-conducting vessels and agreed with Ludwig (1952) that this material might be pectic in nature. These studies focused attention on the role of pectic enzymes in causing the plugs. Pectins are found in considerable quantity in tomato stems, and form the middle lamellae by which cells are cemented to one another. Pectic substances are exposed in xylem tissue wherever pits occur in the walls of vessels.

F. oxysporum f. *lycopersici* produces two types of pectic enzymes: pectin methyl esterase and polygalacturonase (Gothoskar *et al.*, 1953; Pierson *et al.*, 1955; Waggoner and Dimond, 1955). The pectins consist of polymers of galacturonic acid, in which some of the carboxyl groups are esterified by methoxy groups. Pectin methyl esterase hydrolyzes these ester linkages, leaving polygalacturonide chains that are then subject to attack by polygalacturonase. Polygalacturonase hydrolyzes these long chains, reducing their length partly or completely to galacturonic acid. The polygalacturonides form highly viscous sols, which under suitable conditions set to gels. When an enzyme attacks a polygalacturonide chain centrally, viscosity of the solution decreases and reducing groups appear slowly. If this reaction does not continue, the residual polygalacturonide retains some of its viscous properties and gel-forming ability.

One can visualize what happens in the vessel element of a diseased plant when pectic enzymes are present. Pectins exposed at pits in vessels are attacked by the enzymes excreted by fungal mycelium. Pectin methyl esterase converts the pectic materials to substrates for polygalacturonase. These enzymes then attack the pectic substances, which at this stage are still a part of the vessel structure. Some of the hydrolytic products of high molecular weight are dislodged and move into the water stream. Here they interfere with water transport through stems and petioles. The enzyme does not continue hydrolysis because it is rapidly diluted in the transpiration stream.

This is the picture as portrayed by Waggoner and Dimond (1955), by Dimond (1955), and by Walker and Stahmann (1955). That this picture is essentially correct has been shown recently by McDonnell (1958). Mutants of *F. oxysporum* f. *lycopersici* of the highly virulent R-5-6 strain were produced by exposure to ultraviolet radiation. The wild type produces both pectin methyl esterase and polygalacturonase, whereas the mutant produces only pectin methyl esterase. When inoculated into tomato, the wild type causes severe wilting, collapse of leaves, and death of the plant, whereas the mutant is less pathogenic and causes the yellowing and shriveling of the leaves, vascular browning, and some plugging of the stem. Evidently, the pectin-hydrolyzing enzyme is responsible for the severe wilting and collapse of leaves.

Vascular Browning

The discoloration of vascular strands of infected plants rarely occurs far in advance of the invading mycelium. The first sign of browning of invaded vascular bundles is seen in the living xylem parenchyma cells, adjacent to the dead, water-transporting vessels. As browning of these cells becomes more conspicuous, discoloration appears in the vessels also. This browning is probably caused by melanoid pigments, produced by the oxidation of phenols in the living cells.

There is reasonable evidence for this. When certain phenols or polyphenols are absorbed into the vascular system of healthy tomato cuttings, they cause a browning of the vascular system in xylem parenchyma that is indistinguishable from that of *Fusarium*-infected stems. How can phenols arise in diseased plants but not in healthy ones? Many plant cells contain phenolic glycosides, but these compounds are unavailable for melanoid pigment formation unless the glycoside is hydrolyzed. Does the pathogen, perhaps, produce an enzyme that is capable of splitting phenolic glycosides? This possibility was examined by Davis *et al.* (1953), who showed that the fungus can grow on a medium containing a glycoside as the sole carbon source. To obtain carbohydrate, the fungus obviously must split the glycosidic linkage. Glucosidase was found abundantly in the culture medium. Moreover, glucosidase activity was detected in the tracheal sap of *Fusarium*-infected tomato plants, but not in healthy ones.

This enzyme probably enters living xylem parenchyma cells after they have been slightly macerated by pectic enzymes. Once the glycosidase enters, hydrolysis of phenolic glycosides proceeds, and free phenols are liberated. Then terminal oxidases in these cells oxidize the phenols, first to quinones and then to dark-colored melanoid pigments. As this process continues, injury to the parenchyma cells increases, and some of the pigments or their precursors escape into the vessel, which then itself becomes discolored.

Shriveling of Leaves

Many who have worked on the pathogenesis of wilt diseases have considered the possible role of toxins. Toxic compounds of low molecular weight, produced by the pathogen, can be translocated in the plant ahead of fungal mycelium and can readily account for the development of disease symptoms in advance of the invader.

In the *Fusarium* wilt diseases, at least one such vivotoxin is now known to function in symptom production. Fusaric acid has the structure 5-*n*-butyl picolinic acid and is produced by *F. oxysporum lycopersici* and by other *Fusaria* in culture. Also, this compound has been detected in *Fusarium*-infected but not in healthy plants (Kern and Sanwal, 1954; Laksminarayanan and Subramanian, 1955). When absorbed by tomato cuttings, fusaric acid causes first the development of lesions, followed by

shriveling of leaves. The manner in which fusaric acid functions in pathogenesis has been discussed by Gaumann (1957).

Summary

The wilt diseases have a characteristic syndrome. Several separate biochemical mechanisms are involved in the production of these symptoms. In some cases a product is produced by the pathogen and acts directly on the host. In others, components of the host further modify the course of events and contribute to the production of symptoms. The picture presented for symptom development in *Fusarium* wilt of tomato is probably typical of that for other *Fusarium* wilts and is pertinent in accounting for the symptoms of other wilt diseases as well.

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II. THE ROLE OF TOXINS AND OTHER METABOLITES IN THE CAUSATION OF DISEASE IN PLANTS*

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I propose in this paper to deal with problems relating to the physiology of parasitism and to indicate the manner in which plants respond to the activities of different types of disease-producing organisms.

Infectious diseases of plants may arise as a result of an interchange of metabolites between a pathogenic organism and an invaded host. The host provides the nutrients that enable the invading pathogen to grow and develop, while the pathogen, during its growth within a host, elaborates metabolites that may be harmful to the plant. The biologically active substances produced by different types of pathogenic organisms during the course of infection differ widely in chemical structure and, correspondingly, in the type of response that they elicit from a host. I propose now to illustrate these points with the use of a number of selected but representative examples.

One of the first and, to this day, perhaps the best understood example of the physiology of parasitism in plants is the now classic study on the soft-rot disease of carrots and certain other vegetables that was carried out by L. R. Jones shortly after the turn of the century. Jones[1] demonstrated, with the use of a series of rather elegant experiments, the role of a specific enzyme produced by a specific bacterium in the causation of a specific disease. The soft-rot bacterium, *Erwinia carotovora*, produces an enzyme, which has been called protopectinase, that specifically degrades the middle lamella of storage parenchyma cells, causing those cells to lose their cohesiveness. The protoplasm of the separated cells collapses, and the affected tissue decays. Pectin-degrading enzymes are also believed to be largely responsible for the wilting observed in the Fusarium wilt disease of tomato.[2,3] In this instance the fungus invades the xylem vessels of a susceptible plant and produces at least two types of pectin-splitting enzymes, which diffuse into neighboring regions where they cleave pectic materials to form relatively large soluble pectic fragments. These fragments move into the vessels, where they gel to form plugs and occlude the vessels. The pectic plugs impede the normal flow of water and nutrients which, in turn, results in a wilting and ultimate death of an affected plant. The mechanism of wilting in certain other diseases appears to be quite different. A number of glucosans and fructosans isolated from pathogenic bacteria has been found to induce wilting in tomato cuttings.[4,5] Wilting similar to that caused by bacterial slimes can be induced in plants by introducing synthetic poly-

*This paper, illustrated with slides, was the second of two papers presented at a meeting of the Division on April 24, 1959.

vinyl alcohols or polyethylene glycols into the vascular region.[6] The wilting efficiency of the synthetic polymers can be correlated with their molecular weight. Since these polymers contain no specific functional groups capable of imparting wilting activity to the molecule, it was assumed that these substances were injurious because they occlude the vessels in a plant and thus interfere with transpiration.

We have considered briefly large molecular weight compounds, enzymes and polysaccharides, that act directly or indirectly in a physical manner to induce disease in plants. I now call attention to those metabolites that are themselves highly toxic and act as general protoplasmic poisons. An example of this type of metabolite is the toxic substance associated with the wildfire disease of tobacco. Wildfire is characterized by localized chlorotic leaf haloes 1 to 2 cm. in diameter that surround a centrally located brown necrotic spot. The chlorotic area is free of bacteria, and results from the diffusion of a toxic substance secreted by the bacteria present in a central necrotic focus of infection. In young seedbed-grown plants this toxic metabolite may become systemic, diffusing throughout the plants and causing a stunting and ultimate death of the affected seedlings. The biologically active substance can be freed of the bacteria by filtration, and the sterile culture filtrates are capable of reproducing perfectly the toxic manifestations of the wildfire disease not only in tobacco but in a large number of plant species that are not themselves susceptible to infection by the causal bacterium.

In studying the mode of action of the wildfire toxin, the initial experiments were transferred from the level of the whole plant to free-living plant cells. In these investigations the alga *Chlorella vulgaris* was used as the test object.[7] When the toxic metabolite was incorporated into an otherwise suitable culture medium, it inhibited the growth of *Chlorella*. This growth inhibition was reversed competitively with L-methionine, indicating that the toxin and methionine were competing for active centers on an enzyme that is normally concerned in the utilization of methionine by *Chlorella*. This view was further strengthened when it was found that the known structural analogue of methionine, methionine sulfoximine, reproduced perfectly the toxic manifestations of the wildfire disease when applied to a tobacco leaf. This compound, which causes convulsive seizures known as running fits when fed to dogs, rabbits, and mice, inhibits the growth of *Chlorella;* as in the case of the wildfire toxin, this inhibition is reversed competitively with methionine. Mutants of *Chlorella* selected for resistance to the wildfire toxin were found to be equally resistant to comparable concentrations of methionine sulfoximine. The reverse was also found to be true. This, together with studies carried out on the chemistry of the toxin by D.W. Woolley, indicates that the wildfire toxin is a structural analogue of methionine that owes its biological activity to its behavior as a naturally occurring antimetabolite of that essential amino acid. Although the wild-

fire toxin is nonspecific in that it acts as a general protoplasmic poison, it is highly specific in its mode of action within the cell, for there it acts to block a clearly defined link in a metabolic sequence of events. This results in the development of a unique type of nutritional deficiency which, in turn, is responsible for the development of the characteristic lesion.

Of perhaps greater biological interest than the toxic metabolites that act as general protoplasmic poisons are those that show great specificity of action. A number of examples of this type could be cited, but again I shall deal briefly with a system with which we have had some experience. The fungus *Helminthosporium victoriae* elaborates a highly destructive toxic substance for oat varieties bearing victoria genes. This substance is innocuous when applied to resistant oat varieties. Susceptibility to the toxin is dominant and is inherited in a simple 3:1 Mendelian ratio, indicating that resistance or susceptibility is mediated by the action of a single gene.

The toxic substance has now been isolated, and it has been found to be polypeptide in nature.[8] This substance is biologically very active, and as little as 0.01 of a millionth of 1 gm./ml. will give rise to a typical lesion when applied to susceptible oat varieties. It is also one of the most selective toxins known, since the only organisms found thus far to be susceptible to its action (many species of bacteria as well as higher and lower plant forms have been tested) are oat varieties bearing victoria genes. This toxic metabolite is composed of two components.[9] One of these is a pentapeptide that yields aspartic acid, glutamic acid, glycine, valine, and one of the leucines on hydrolysis. The second component, given the trivial name Victoxinine, has the empirical formula $C_{17}H_{29}NO$. This compound is a tricyclic secondary amine with a single double bond. The linkage between the peptide and the secondary amine is labile and readily cleaved with dilute alkali. It seems to involve the amino groups of both the peptide and the secondary amine, since the intact toxin does not react with ninhydrin, while both components do react with that substance. The labile linkage is more stable than an electrostatic linkage, since cleavage in the presence of dilute alkali is not instantaneous.

It is interesting to note that the secondary amine is toxic to both susceptible and resistant oat varieties. This suggests that the secondary amine may be responsible for the toxicity of the toxin, while the specificity of that compound may be a function of the peptide portion of the molecule. The physiological basis of susceptibility or resistance to the intact toxin may thus be determined by the ability of this compound to enter cells of susceptible but not of resistant oat varieties, a property conferred on the secondary amine by the peptide moiety.

Not all metabolites elaborated by plant pathogenic organisms injure or kill the cells of the host. Some stimulate plant cells to excessive growth. Intensified but harmonious manifestations of normal developmental potentialities have been recorded in a number of plant species following infec-

tion by a variety of fungi. The best understood of this type of disease is the Bakanae disease of rice, which is caused by *Gibberella fujikuroi*. Rice plants infected with that fungus grow much taller than do their normal counterparts, but they have an etiolated appearance. In 1926 Kurosawa [10] demonstrated that the growth-stimulating effects accompanying the Bakanae disease could be reproduced in rice seedlings by treating them with sterile culture filtrates on which the causal fungus had grown. This pioneer work was followed by the isolation of four biologically active compounds now known as gibberellin A^1, A^2, A^3, and A_4. [11] These substances differ from each other in level of oxidation. Gibberellin A_1 has now been isolated from higher plant material, and it doubtless represents an important type of endogenous growth regulator in normal plant metabolism. The gibberellins appear to exert their physiological effects by removing inhibitions to cell enlargement, while incidentally releasing other responses.

In contrast to the metabolites such as the gibberellins, which induce intensified but harmonious manifestations of normal developmental potentialities, are the metabolites that modify greatly the morphology of a plant. An example of this type of response is a condition known as frenching of tobacco. Frenching is characterized in an advanced stage by loss of apical dominance and a resulting development of axillary shoots accompanied by the formation of unusually large numbers of leaves. The leaves assume an upright growth habit and are commonly sword- or string-shaped. Steinberg [12, 13] has suggested that this condition is caused by a toxic metabolite secreted by the nonpathogenic soil bacterium *Bacillus cereus*. The progressive development and type of symptoms obtained with the use of sterile culture filtrates of this organism largely parallel those that appear in plants subject to this condition in the field. Steinberg [13] showed, further, that slightly excessive amounts of certain amino acids such as the natural isomers of isoleucine and alloisoleucine caused the development of frenching symptoms in tobacco seedlings. Analytical studies showed, [14] further, that frenching was accompanied by a marked increase in isoleucine and other free amino acids in the leaf lamina of field-grown plants. The absence of free amino acids in frenching soils and the marked increase of free isoleucine in frenched leaves indicate that the *B. cereus* toxin and isoleucine are not identical. It was concluded, therefore, that the accumulation of excessive amounts of isoleucine and other free amino acids in the frenched leaves as a result of the action of the toxin is a probable chemical factor in the development of the morphologic abnormalities that characterize frenching.

Let us now examine metabolites that induce loss of typical organization in a plant. There exists in plants a vast array of distinct types of growth abnormalities that are of a self-limiting type. These excrescences commonly result from the activities of specific bacteria, viruses, slime molds, fungi, nematodes, mites, and insects. They are characterized by the fact

that their continued growth is dependent upon continued stimulation by the invading parasite.

Metabolites produced by parasites to stimulate the plant cells to excessive growth appear to be of many different kinds. Some seem to be relatively nonspecific and to have no special organizing properties. In these instances a parasite may model a gall characteristic of its species by introducing such chemical substances into plant cells in an orderly fashion, spatially, temporally, and quantitatively. At other times these substances appear to possess highly specific organizing properties that tend to divert the normal growth pattern of a plant into new and quite unusual directions. In the prosoplasmatic insect galls, for example, the typical organization of a plant undergoes orderly qualitative changes which, in their most interesting form, reveal growth and developmental potentialities quite different from any realized during normal growth and development. The morphology of galls of this type produced by different but closely related insect species is very different. Some are smooth, others are warted or rugged, while still others are covered with finely dissected velvety leaves or with spines or claws. Some are spherical in shape, others star-shaped, while still others have the appearance of a trumpet. From observations such as these it is clear that plant tissues are formed and fashioned very differently from what they would be without the influence of the biologically active chemical substances produced by the insects. Although an insect gall is built from the cells of the host, there is no question about the fact that the morphologic form that a gall assumes depends upon the species of insect that initiates it. The same plant attacked by a number of different but closely related insect species will produce a morphologically quite distinct gall in response to the stimulus produced by each of the different insect species. All of this seems to indicate that highly specific morphogenetic stimuli of a chemical nature are elaborated by certain insects and that these substances are capable of initiating, stimulating, and directing most precisely the development of plant cells into new and unusual directions. Unfortunately, very little experimental evidence is as yet available to establish the truth of this view.

In addition to the large number of self-limiting growths, there are produced in plants nonself-limiting tumors that have no characteristic size or structure.[15] These may be initiated by very different types of agencies. In at least one instance, the crown gall disease, the inciting bacterium *Agrobacterium tumefaciens* elaborates a tumor-inducing principle that converts normal plant cells to tumor cells in short periods of time. Such tumor cells acquire, as a result of their transformation, a capacity for continued abnormal and essentially unregulated growth in the absence of the inciting organism. This leads to the development of massive tumorous growths that, in extreme instances, may weigh as much as one hundred pounds. Such tumors are potentially malignant, and they may seriously

damage or kill the plants on which they develop. From a broader biological point of view, the tumor-inducing principle associated with this disease is doubtless the most interesting of the biologically active agencies considered here, since it induces a profound and permanent change in the subsequent behavior of an affected cell.

Although a number of quite distinct agencies can initiate the tumorous state in plants, the physiological basis for the continued abnormal and autonomous growth of the tumor cells appears to be quite similar regardless of the initiating cause. The transition from a normal plant cell to a tumor cell appears to involve the excessive production by the tumor cell of two intracellular growth hormones that are concerned specifically with processes of cell enlargement and cell division.[16] Certain other metabolites essential for growth are also synthesized by the tumor cells in greater than normal amounts. The continued production of these growth-promoting substances in greater than regulatory amounts by the tumor cell accounts for the continued abnormal and essentially unregulated growth of those cells. These growth-substance-synthesizing systems are precisely regulated in all normal plant cells. The mechanism by which any one of several tumor-inducing agencies activates the enzymatic machinery of the cell and thereby causes it to produce excessive amounts of growth-promoting substances is not yet clear.

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DIVISION OF ANTHROPOLOGY

SOCIAL STRUCTURE AND ACCULTURATION AMONG THE KANURI OF BORNU PROVINCE, NORTHERN NIGERIA*

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This paper is a preliminary report of research undertaken among the Kanuri of Bornu Province, Northern Nigeria, West Africa with the purpose of investigating the relationship between the social structure of a community and the process of acculturation, in which Kanuri culture has undergone changes as a result of contact with generalized industrial European culture.

Acculturation has been studied intensively from several points of view by United States anthropologists: the most common approach has been the attempt to explain culture changes in terms of personality variables isolable in individuals exhibiting acculturated behavior. Another approach has been the attempt to ascertain which areas of cultural behavior (such as economic, technological, and ritual) have been most susceptible to outside influences, which have been fundamental in bringing about changes in other areas, and which have been the areas most resistant to change.

The position adopted in this paper is that such formulations are simplistic in that they omit particularly crucial variables in the culture contact situation.

Theoretical Orientation

Raymond Firth has said: "It is becoming increasingly clearer that in order to understand both change in structure and change in detail we must look to a closer study of the setting and results of individual choice and decision as they affect activity and social relations. In other words, we must look to analysis of social organization to help in the understanding of social change. In this too, we must be prepared to quantify much more of the data."[1] The theoretical framework adopted here derives from Firth's writings on social organization.[2,3] The present study does not represent an attempt at verification of hypotheses suggested by Firth. Rather, it is an attempt at integration of some of the concepts of social anthropology within the larger conceptual framework of culture. In so doing, it is hoped that the introduction of concepts concerning social structure will provide an added dimension to the study of acculturation.

*This paper, illustrated with slides, was presented at a meeting of the Division on April 27, 1959. The field work on which it is based was conducted between June 1956 and September 1957, and was made possible by a fellowship granted by The Ford Foundation, New York, N.Y. However, the conclusions, opinions, and other statements in this article are those of the author and not necessarily those of The Ford Foundation.

The concept of culture, as used in this paper, refers to norms of classes of behavior pertaining to different areas of life. Economic behavior represents one class of behavior; political behavior represents another. Culture is integrated in that these classes of behavior are functionally interrelated. Each class represents an area of culture, so that we shall speak of such areas as the economic area of culture, and the educational area.

Since cultural behavior always has reference to a particular group of individuals, other concepts dealing with social groups and their interactions become necessary in considering culture. Various types of groups, such as kin groups and local groups, perform activities in the various areas of culture. Seldom will a group perform one and only one type of behavior; rarely will a particular class of behavior, an area of culture, be carried out by only one group.

For comparative purposes, the structure of groups performing activities is one of the most useful variables in relating areas of a culture to one another, or in comparing areas of culture cross-culturally.[4,5] Implicit in the present discussion is a distinction between the social structure of a group that may be conceived of as a network of positions and the role network to which it corresponds.[6] According to Firth, the structure of society provides a reliable guide to action. Variation is found in the social organization, the systematic ordering of social relations by acts of choice and decision. "In the aspect of social structure," says Firth, "is to be found the continuity principle of society; in the aspect of organization is to be found the variation or change principle—by allowing evaluation of situations and entry of individual choice."[7]

In the context of acculturation situations, the theoretical view stated above would demand the consideration of culture change in terms of the structuring of groups within the community. Groups making up the social structure behave in a number of cultural areas. Members of a group exhibit variations in their behavior and in their attitudes that are potentials for behavior as they excercise choices and make decisions. When these choices and decisions represent variations that are consistently in one direction, away from cultural norms, then culture change is occurring in that group. If this consistent acceptance of new choices continues for a sufficiently long period, it will produce new interactions between individuals that will result in the formation of new groups. The social structure will then have been altered.

Although the activities of particular groups are never confined to a single cultural area, the differing groups making up the total social structure of a large community do not perform activities that are randomly distributed over the various areas of culture. The major activities of a group may be economic, political, religious, educational or familial. The decisions with which members of a group are faced will be mainly in certain areas. Furthermore, new choices brought about by contact with other cul-

tures will be largely in those areas in which the group carries out its major activities. A group whose main activities are economic will be faced with new choices in economic activities brought about by culture contact that enlarges the economy.

The present study advances the following hypotheses:

(1) Groups making up the social structure of a community vary in their degree of acculturation.

(2) Groups in the social structure acculturate in different areas of culture at different rates. These differences are determined by the relation of the groups to the cultural area.

(3) Principles governing the relationship of groups to one another in the social structure will affect the rate and degree of acculturation of groups. This relationship to other groups encourages or inhibits variations from the cultural norms.

Ethnographic Background

These hypotheses were tested in the field in a study of Kanuri acculturation to European Culture. The Kanuri number about one and one-half million and form the dominant element of the population of Bornu Province in far northeastern Nigeria. At one time they were a powerful conquest state located on the Sudanese terminus of an important trans-Saharan trade route. Although it is under British colonial rule, Bornu is an emirate with the shehu of Bornu at its head. The shehu appoints district heads, with the approval of the British Resident of the province. The district head, assisted by village heads, by a professional staff, and by his own retainers, collects taxes and sees to it that his district runs smoothly.

Kanuri economy is based on millet agriculture; in recent times, however, peanuts have become an important additional cash crop. A number of European trading companies buy the produce of the area including peanuts, sheep and goat skins, and cowhides, and sell a wide variety of goods manufactured abroad. The Kanuri are a commercial people and internal trade is well developed. Trade between various ethnic groups in the area is important; Fulani and Shuwa Arab herders exchange their dairy products with the settled Kanuri agriculturalists. Every town has a market place and a weekly market. A fair proportion of the population is engaged in trade, some as wholesale middlemen dealing with the European trading companies, others as local tradesmen operating between the larger Kanuri traders and the smaller towns and villages spread over the countryside. The trading group acts to link the internal economic system of the area with the world economy of which the Kanuri are, in a sense, a part. Cloth is one of the most important imports. One of the consequences of this has been the disappearance of weaving. However, a wide range of other crafts is still practiced.

The Kanuri have been Moslems for centuries. Islam is well integrated

into their culture and affects many areas, notably marriage and the family, education, and the legal system. A class of Koranic scholars called *malams* exists in all large communities. The *malams* are highly respected for their learning; children are sent to the *malams* to learn to pray and to study the Koran.

With the coming of the British in Nigeria, a modern educational system was begun, with instruction in English. Kanuri schoolteachers, themselves products of the new educational system, now teach in all the schools. Graduates of these schools also work as agricultural and veterinary assistants, dispensers, sanitation inspectors, and other such professional functionaries. This new class is respected, and its members are also referred to as *malams*.

The Social Structure of the Community

The town of Geidam, situated on the Komodugu Yobe River about 25 miles south of the border between Nigeria and French West Africa, was chosen for study. Geidam has a population of 11,032 and is an active trading center, purchasing produce and distributing goods over a wide radius that extends into French territory. It is also the political center of Geidam district, the largest district in the province, with a population of 86,993. A district head lives in Geidam, along with his large administrative staff. The town also has a courthouse, a large central mosque and many smaller ones, a primary school, a dispensary, a jail, and an agricultural station. Six of the large trading companies have offices in Geidam; 3 of these are run by Europeans, the only Europeans living in Geidam.

The market area is very large. Several thousand individuals are present at the Geidam Wednesday markets; some may come from villages 8 or 10 miles away. Many cattle are slaughtered in Geidam. In the town itself there are many small canteens that retail a wide variety of imported goods.

Geidam is divided into 3 wards, each with its own village head. Two of these wards are Kanuri wards; the third is Hausa, with a Hausa village head. In the Hausa ward there also live Ibos, Yorubas, and members of a range of ethnic groups. A small pagan village is adjacent to the large town. The wards exhibit some degree of craft specialization: the mat makers are largely in one ward, the tanners in another, and the blind, who make rope, all live in one neighborhood of one ward.

The town is surrounded by fields that extend for about three miles. Almost all the people living in Geidam farm a plot in addition to conducting their other activities. They grow millet and peanuts. Since the growing season is limited to the four or five months during which there is rain, it is possible to be a specialist and to farm a plot as well. Very few people are full-time specialists in a strict sense, yet everyone living in the town does something in addition to farming. Many are in trade; many are craftsmen and artisans; still others are engaged in political activities or are religious specialists.

Several locales are intense centers of town activities. The market is one. The mosque becomes a center of communal activities on Fridays. The house of the district head is always a center for a large group of individuals, particularly on those ceremonial occasions when the entire town comes to watch displays of horsemanship in which the men of the district head pay homage to him. The court, the school, the canteens are all minor centers of activity. Lastly, the various neighborhoods, particularly the houses of important men, are such centers.

The Kanuri are bilateral in descent and do not have corporate kin groups of any kind. The household performs many of the functions frequently encountered in the kin group. Important, wealthy, prestigeful individuals have large compounds in which many people are housed. This is a type of local group, since bonds between household members are not necessarily bonds of kinship, but may include a wide variety of links. Living in the household of an important man may be servants, employees of the household head, children given to him to be reared in his house, slaves of his family, and Koranic scholars whom he supports.

Social Groups

Eight social groups were selected for intensive study after a general analysis of community structure had been completed. These groups were selected because they represented groups whose activities were largely involved with specific cultural areas. The groups and their membership are:

(1) *The political aristocracy.* This group includes the district head, a current village head, a former village head, an aide of the district head who had been offered a village headship but had refused it, and a nephew of the district head who held a minor political appointment.

(2) *The bureaucratic retainers.* Members of the large group who serve as tax collectors but preserve many of the feudal-like characteristics of pre-British times. All have been given horses belonging to the district head, and the houses in which they live. This group of about sixty individuals has a complex internal structuring. Many of its members are slaves of the district head, and this added dimension operates in further complicating the structure of the group. Six members of this group were chosen for study.

(3) *The Koranic scholars.* Three members of this class were chosen for study: the Imam of Geidam, who leads the weekly Friday prayers, the Imam who leads prayers on holy days, and the *malam* attached to the household of the district head.

(4) *The professional class.* Six members of this class were selected. They have all been educated in the British school system, speak English with varying degrees of proficiency, and work for the Bornu Native Authority in various capacities. They are: the town scribe, the town treasurer,

the headmaster of the local primary school, the local dispenser, the agricultural *malam,* and the veterinary *malam.*

(5) *The traders.* Six members of the group of large wealthy traders, wholesalers who act as middlemen between the European companies and local retailers at various levels. Five of the six members of this group are *Alhajis;* they have made the pilgrimage to Mecca.

(6) *The craftsmen.* Six of the large class of full-time specialists living in Geidam. The six comprise: two house builders, two leatherworkers, a dyer, and a barber. Most of these crafts are organized as groups with their own heads, who arbitrate disputes between members of the group.

(7) *The commoners.* Eight members of the very large class of people living in Geidam who are not full-time specialists, yet perform some nonskilled activity in addition to farming. These include four small retailers in the Geidam market (sellers of sundry goods, kola nuts, and robes), a man who sews horse blankets sold in the market, a laborer working for one of the European companies, a seller of almost anything for a commission, and a low-level retainer of the district head who has no horse.

(8) *The low-status class.* Certain occupations traditionally have a low status in Kanuri culture. They are usually, though not always, passed on from father to son. Men in their occupations are full-time specialists, but they have a special position in the social structure. The four individuals in this group are: a drummer and praise-singer, two tanners, and a butcher (the only Kanuri among perhaps forty butchers who serve Geidam).

Of the eight social groups described above, some exhibit strong integrative group qualities, others resemble classes or categories of individuals more than groups. However, all posses the two characteristics necessary for testing the proposed hypotheses. Each occupies a place in the community social structure with respect to other groups, and their major activities are in particular cultural areas.

The Scale of Acculturation

Measures of acculturation were devised in the field that would refer to a variety of behavioral areas. These are not universal measures of acculturation that would be applicable to all cultures. They were devised to measure acculturation among the Kanuri, and are therefore referable only to a particular cultural context. The behavioral areas to which they refer, however, are found in all cultures. In this respect the scale is cross-culturally valid.

The measures of acculturation were obtained for the 44 individuals in the 8 groups described above through a long questionnaire-interview administered in Kanuri. The questionnaire-interview took 2 hours to give, and included 75 questions, many of them complex. Thirty of these rated acculturation in the following behavioral areas: possession, use, and knowledge of Western material culture; evaluations of the usefulness of such items; religious behavior; and attitudes toward Western medical

practices and the effectiveness of such treatment, toward traditional ways of arbitrating disputes, toward traditional forms of Kanuri generosity, toward preferred types of occupations for the individual and for his sons, toward education of both sons and daughters, toward marriage with women outside Kanuri culture and with acculturated Kanuri women, and toward the behavior permitted one's wife. Fourteen of the 30 questions used have been selected for presentation here (TABLE 1). These are all questions with yes-no answers. The remaining 16 questions require more complicated handling, since each answer must be rated as to the degree of acculturation shown. The questionnaire-interview was administered in the last 2 months of field work, after intimate knowledge of Kanuri culture and of the town of Geidam had been acquired.

TABLE 1

ITEMS USED IN THE ACCULTURATION QUESTIONNAIRE

(1) Can you ride a bicycle?
(2) Can you tell time?
(3) Which would you rather own, a horse or a bicycle?
(4) Do you smoke cigarettes?
(5) Would you wear European-made shoes?
(6) Would you wear European-style trousers?
(7) Would you go to a European doctor if you were sick?
(8) Would you send your daughter to the European school?
(9) Would you marry a non-Kanuri woman?
(10) Would you marry a Kanuri woman who had gone to school and spoke English?
(11) Would you let your wife go to work as a dispenser or as a schoolteacher?
(12) Would you want your sons to go to the European school?
(13) Who knows more about setting bones, a Kanuri practitioner or a European doctor? About treating jaundice? About treating snake bite? About treating a headache? About treating smallpox? About treating internal pains?
(14) Would you marry a Fulani woman? A Hausa woman? A Moslem Babur woman? A Moslem Yoruba woman?

Results

The questionnaire was given to members of the 8 social groups described, and their answers were classified as acculturated or unacculturated (TABLE 2). The proportions of acculturated to unacculturated answers for the different groups are compared to determine whether the 8 groups differ from one another. This comparative procedure is used throughout in testing the 3 hypotheses cited above. In the remaining sections of the paper these group differences will be analyzed statistically, and the precise nature of these differences will be discussed in terms of the theoretical position set forth earlier.

(1) Hypothesis 1 is tested on the data presented in TABLE 2. In compiling the data included in TABLE 2, the first 12 questions are treated together, and the 8 groups are compared according to their total yes-answers and their total no-answers. Combining the 12 questions results in a general measure of "degree of acculturation" that merges the different areas

in which acculturation takes place. A chi-square test was performed on the data presented in TABLE 2. The chi-square value for the table was 33.8. With 7 degrees of freedom, this is significant at the 0.001 level (the given results might have occurred one time in a thousand by chance). Hypothesis 1 has therefore been upheld; the 8 social groups selected for study exhibit differing degrees of acculturation.

(2) However, the results obtained from TABLE 2 are insufficient to test hypothesis 2, precisely because different behavioral areas are merged in TABLE 2. In order to test hypothesis 2, behavioral areas must be considered individually. This has been done in TABLES 3 and 4.

TABLE 2

Numbers in the Second and Third Columns Represent the Answers to the First Twelve Questions in TABLE 1, Divided into the Total No Answers for a Group and the Total Yes Answers.

Groups	*Acculturated (yes)*	*Unacculturated (no)*
Political aristocracy	47	13
Bureaucratic retainers	40	32
Koranic scholars	12	24
Professional class	56	16
Traders	41	31
Craftsmen	36	36
Commoners	56	40
Low-status class	25	23
Totals	313	215

In TABLE 3, three of the 8 groups have been compared in their attitudes toward knowledge of the treatment of 6 diseases (question 13). The 6 answers, for the 6 types of diseases, have been treated together. An answer stating that Kanuri knowledge about the treatment of the disease is superior is rated unacculturated; an acculturated answer states that European knowledge is superior. The chi-square value for TABLE 3 is 7.3. With 2 degrees of freedom, this is significant at less than the 0.05 level of significance. TABLE 3 therefore demonstrates that in a particular behavioral area, attitudes toward the treatment of disease, different groups will exhibit varying degrees of acculturation. However, TABLE 3 provides much more significant information. Referring once again to the information in TABLE 2, it will readily be seen that the political aristocracy is a highly acculturated group when compared with the commoner group and with the bureaucratic retainers. However, TABLE 3 shows that in evaluations of medical knowledge the political aristocracy is very unacculturated; the bureaucratic retainers are very acculturated; and the commoner group falls between the two.

Further demonstration that the general "degree of acculturation" measured in TABLE 2 is composed of many variables drawn from different be-

havioral areas, whose effects when combined may act to cancel one another out, may be seen in TABLE 4. TABLE 4 compares 3 of the 8 groups in their attitudes toward marriage with women of 4 non-Kanuri tribes to obtain a measure of willingness to marry out; the answers have all been treated together. The chi-square value for TABLE 4 is 7.88. This is significant at the 0.02 level of significance. Again note that the traders, who in TABLE 2 appear as a moderately acculturated group, are markedly unacculturated in this particular area.

From the results obtained in TABLES 3 and 4 it is apparent that a measure of general degree of acculturation is misleading, since groups respond differently in different cultural areas. Thus, hypothesis 2 is upheld.

(3) However, our data enable us to proceed still further. Although the data are not presented here in their entirety, the groups compared in TABLE 3 have not responded uniformly to separate questions on the six diseases. Particularly striking is the response of the political aristocracy in its attitude toward the treatment of smallpox. This group unanimously claimed that Kanuri practitioners knew more about the treatment of smallpox than did the European doctor. The remainder of the population overwhelmingly chose the European doctor. Of the six diseases, smallpox is the only one for which treatment (inoculation) is sponsored and carried out by supradistrict political authorities. The local political aristocracy will not place its faith in a type of medical treatment that is administered by a superior political authority.

Similarly, the data in TABLE 4, when broken down to their constituent parts, reveal that the traders as a group are indeed conservative about whom they choose to marry, but this conservatism does not extend uniformly to all four tribes. The traders will not marry Babur, Yoruba, or Fulani women, but they will marry Hausa women (the numbers are too small to treat statistically). In this they differ from other groups which show no preference for Hausa over women of other tribes. The explanation, in complete accordance with hypothesis 2, is that the Hausa are the important trading group in Northern Nigeria. Kanuri traders all speak Hausa fluently and come into frequent contact with Hausa. Therefore, they have no objection to marrying Hausa women.

Hypothesis 2 helps to explain why traders do not object to marrying Hausa women. Why should they be more conservative than other groups in objecting to marry Babur, Yoruba, and Fulani women? The answer to this becomes more apparent when one examines the traders as a group, comparing them with the remaining 7 groups as regards each of the first 12 questions used in TABLE 1. The traders are more acculturated than the bulk of the population in their responses to 5 questions (questions 1,3,5, 7,10); unacculturated in 4 questions (4,6,9,11); close to the others in their responses to the remaining 3 questions. The areas in which their responses proved to be acculturated were: material culture, attitude toward treatment of disease, and marrying an educated woman. The traders were unaccul-

turated with respect to: smoking cigarettes and wearing trousers (non-utilitarian items of European culture), marrying a non-Kanuri woman, and letting their wives work.

TABLE 3

Numbers in the Second and Third Columns Represent Answers to the Six Parts of Question 13 Treated Together, and Divided into Two Columns: Acculturated (European) and Unacculturated (Kanuri) Answers

Groups	*Acculturated (Eur.)*	*Unacculturated (Kan.)*
Political aristocracy	9	21
Bureaucratic retainers	21	12
Commoners	23	25
Totals	53	58

TABLE 4

Numbers in the Second and Third Columns Represent Answers to the Four Parts of Question 14 Treated Together, and Divided into Two Columns: Acculturated (yes) and Unacculturated (no) Answers

Groups	*Acculturated (yes)*	*Unacculturated (no)*
Professional class	14	10
Traders	5	19
Commoners	10	22
Totals	29	51

The data presented here on the behavioral areas in which traders were most acculturated and those areas in which they remained unacculturated verify hypothesis 3. These data can best be understood in terms of the principles determining the relationships between groups in the social structure. The traders are a wealthy group, with increasing political power in the town council. They are a new group, however, and they seek ways to increase their prestige and to maintain their positions in the community. Piety is one of the ways to achieve this, and the traders become *Alhajis* as soon as possible. Although their present position is to a certain extent the result of their having moved into a new sphere of activities, in other areas of behavior they closely adhere to cultural norms. In these areas their responses are unacculturated when compared with those of the rest of the population.

Conclusion

It is hoped that in this brief presentation the fruitfulness of approaching the study of acculturation through community social structure has been demonstrated. The three hypotheses that were derived from a general theoretical position have been upheld in the present study of Kanuri culture.

They must, of course, be demonstrated to be true cross-culturally. It is further hoped that this paper has indicated some of the advantages gained in following Firth's exhortation that we must be prepared to quantify much more of our data.

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CONFERENCES HELD

SECTION OF BIOLOGICAL AND MEDICAL SCIENCES

CURRENT TRENDS IN RESEARCH AND CLINICAL MANAGEMENT OF DIABETES

Friday, April 10 and

Saturday, April 11, 1959

Conference Chairman: Peter H. Forsham
University of California Medical Center
San Francisco, Calif.

PROGRAM

FRIDAY, APRIL 10, 1959

DIABETES MELLITUS: CERTAIN FUNDAMENTAL, CLINICAL AND SOCIOECONOMIC CONSIDERATIONS

Session Chairman: Henry Dolger
The Mount Sinai Hospital
New York, N.Y.

9:00 A.M. –
Greetings from the Academy – Charles R. Noback, Secretary, Section of Biological and Medical Sciences, The New York Academy of Sciences, New York, N.Y.; College of Physicians and Surgeons, Columbia University, New York, N.Y.

Introduction – Peter H. Forsham, University of California Medical Center, San Francisco, Calif.

"The Problem of Classification of Diabetes Mellitus" – Max Miller, Western Reserve University School of Medicine, Cleveland, Ohio.

"The Genetics of Diabetes: A Review" – Arthur G. Steinberg, Western Reserve University School of Medicine, Cleveland, Ohio.

"The Early Recognition of Diabetes Mellitus" – Stefan S. Fajans and Jerome W. Conn, University of Michigan Medical School, Ann Arbor, Mich.

"Pregnancy and the Prediabetic State" – Hugh L.C. Wilkerson, U.S. Public Health Service, Boston, Mass.

"The Current Estimate of the Prevalence of Diabetes" – Quentin R. Remein, Public Health Service, Bethesda, Md.

"Diabetes and the Living Microvascular System" – Edward H. Bloch, Western Reserve University School of Medicine, Cleveland, Ohio.

"Diabetic Neuropathy" – Max Ellenberg, The Mount Sinai Hospital, New York, N.Y.

"The Acceptability of Diabetics for Life Insurance" – Paul S. Entmacher, Metropolitan Life Insurance Company, New York, N.Y.

"The Employability of the Diabetic" – Harold Brandaleone, New York University College of Medicine, New York, N.Y.

RECENT ADVANCES IN STUDIES OF INSULIN SECRETION AND CERTAIN METABOLIC EFFECTS

Session Chairman: C. H. Best
University of Toronto
Toronto, Ontario, Canada

2:00 P.M. –
"Islet Cell Function" – R. E. Haist, University of Toronto Faculty of Medicine, Toronto, Ontario, Canada.

"Electron Microscopy of Islets of Langerhans" – Paul E. Lacy and W. Stanley Hartroft, Washington University School of Medicine, St. Louis, Mo.

"Use of the Golgi Apparatus as an Indicator of the Level of Activity of the Cells of the Islets of Langerhans" – Adrienne A. Batts, University of California School of Medicine, San Francisco, Calif.

"Morphologic Reflection of Increasing Insulinogenesis during Chronic Hyperglycemia in the Rabbit" – Bruno W. Volk and Sydney S. Lazarus, The Isaac Albert Research Institute of the Jewish Chronic Disease Hospital, Brooklyn, N.Y.

"The Effect of the Site of Insulin I^{-131} Administration on Its Distribution Between Hepatic and Extrahepatic Tissues" – Mary S. McCall, Susan Keller, and Roger Unger, Southwestern Medical School, University of Texas, Dallas, Texas.

"Studies on the Mechanism of Capture and Degradation of Insulin I^{-131} by Rat Liver" – Glenn L. Mortimore and Frank Tietze, Institute of Arthritis and Metabolic Diseases, Public Health Service, Bethesda, Md.

"Recent Studies on Insulin-Binding Antibodies" – Solomon A. Berson and Rosalyn S. Yalow, Veterans Administration Hospital, Bronx, N.Y.

"Insulin-Stimulated Glycogen Formation in Rat Diaphragm" – Joseph Larner, C. Villar-Palasi, and D.J. Richman, Western Reserve University School of Medicine, Cleveland, Ohio.

"The Regulation of Glucose Uptake by Muscle: Significance of Cellular Permeability and Hexokinase Activity" – David M. Kipnis, Washington University School of Medicine, St. Louis, Mo.

"Role of Insulin in Two Pathways of Glucose Metabolism: *In Vivo* Glucosamine and Glycogen Synthesis" – Robert G. Spiro, Harvard Medical School, Boston, Mass.

SATURDAY, APRIL 11, 1959

MORE ON THE BIOCHEMISTRY AND PHYSIOLOGY OF INSULIN AND THE SULFONYLUREA COMPOUNDS

Session Chairman: Rachmiel Levine
Michael Reese Hospital
Chicago, Ill.

9:00 A.M. –

"The Effect of Nonenergy-Yielding Hexoses on Glucose Permeation of the Cell" – Arne N. Wick, San Diego State College, San Diego, Calif.

"The Glucose Transport Theory of Insulin Action" – M.S. Goldstein, Michael Reese Hospital, Chicago, Ill.

"The Transport of Glucose in Muscle" – Charles R. Park, Vanderbilt University School of Medicine, Nashville, Tenn.

"Effect of Insulin on Adipose Tissue" – George F. Cahill, Jr., Bernard Jeanrenaud, Bernard LeBoeuf, and Albert E. Renold, Harvard Medical School, Boston, Mass.

"Effects of Insulin and Tolbutamide on Blood Glucose Entry and Removal" – A. Gerson Jacobs and Sidney Weinhouse, Temple University, Philadelphia, Pa.

"The Influences of Glucose Loading and of Injected Insulin on Hepatic Glucose Output" – Robert Steele, Brookhaven National Laboratory, Upton, N.Y.

"Effects of Exogenous and Endogenous Insulin on Glucose Utilization and Production" – Richard C. DeBodo, R. Steele, N. Altszuler, A. Dunn, D.T. Armstrong and J.S. Bishop, New York University College of Medicine, New York, N.Y.

"The Effects of the Slow Infusion of Insulin on Hepatic Output of Glucose" – Leonard L. Madison, Burton Combes, William Strickland, Roger Unger and Reuben Adams, University of Texas, Southwestern Medical School, Dallas, Texas.

"The Hepatic Action of Insulin" – Robert Mahler, Queens College, Dundee, Scotland; James Ashmore, University of Indiana, Indianapolis, Ind.; and William Shoemaker, Michael Reese Hospital, Chicago, Ill.

"Further Studies on the Role of the Liver in Sulfonylurea Action" – Thomas F. Frawley, Thomas F. Shelley, John W. Runyan, Edward Margulies and John J. Cinciotti, Albany Medical College and Veterans Administration Hospital, Albany, N.Y.

"Clinical and Experimental Studies of Insulin Secretion Following Tolbutamide and Metahexamide Administration" – Ernst F. Pfeiffer, Margret Pfeiffer, Hans Ditschuneit and Chang-Su Ahn, Dept. of Medicine, Johann Wolfgang Goethe University, Frankfurt/Main, Germany.

THE STATUS OF ORAL AGENTS IN THE THERAPY OF DIABETES

Session Chairman: J. D. Achelis
C. F. Boehringer and Son,
Mannheim-Waldhof, Germany

2:00 P.M. –
Introduction – J. D. Achelis, C. F. Boehringer and Son, Mannheim-Waldhof, Germany.

"Pharmacologic Studies of the Sulfonylureas" – Alfred Baender, Farbwerke-Hoechst AG., Frankfurt (M) – Hoechst, Germany.

"The Role of Oral Blood Sugar Lowering Agents in the Treatment of Diabetes" – Robert F. Bradley, The Joslin Clinic, Boston, Mass.

"An Assessment of Oral Antidiabetic Therapy" – Henry Dolger, The Mount Sinai Hospital, New York, N.Y.

"Correlation of Plasma Levels of Oral Antiabetic Agents with Blood Sugar Responses" – Werner Creutzfeldt, F. Andrea-Kern and R. Discher, University Medical Clinics, Freiburg-Breisgau, Germany.

"Comparative Pharmacology and Clinical Responses to Metahexamide" – George J. Hamwi, Thomas G. Skillman, Lucy R. Freedy, Frederick A. Kruger, and William H. Roush, Ohio State University College of Medicine, Columbus, Ohio.

"Tolbutamide Studies in 'Prediabetes'" – H.P. Barros-Barreto and Lillian Recant, School of Medicine, Washington University, St. Louis, Mo.

"The Relative Effectiveness of the Newer Oral Hypoglycemic Agents in Patients Imperfectly Regulated with Tolbutamide" – Roger H. Unger, Parkland Hospital, Dallas, Texas, Norman Carter, Veterans Administration Hospital, Dallas, Texas, and Leonard Madison, University of Texas Southwestern Medical School, Dallas, Texas.

"Combination Insulin-Tolbutamide Therapy in the Management of Insulin-Dependent Diabetes" – Maximilian Fabrykant, New York University College of Medicine, New York, N.Y., Benjamin I. Ashe, New York University Post-Graduate Medical School, New York, N.Y.

"The Physiologic Basis of the Effectiveness of Combined Insulin-Tolbutamide Therapy in Stable Diabetes" – Sydney S. Lazarus and Bruno W. Volk, Isaac Albert Research Institute of the Jewish Chronic Disease Hospital, Brooklyn, N.Y.

"The Actions of Phenethylbiguanide" – Donald F. Steiner and Robert H. Williams, University of Washington School of Medicine, Seattle, Wash.

"The Biguanides: Their Role in This Era of the Precise Tool" – Leo P. Krall, The Joslin Clinic, Boston, Mass.

"Metahexamide in Diabetes Therapy" – James M. Moss and DeWitt DeLawter, Georgetown University Hospital, Washington, D.C.

"Clinical Studies with Metahexamide" – S. J. N. Sugar, District of Columbia General Hospital, D.C. and Lawrence Thomas, Prince George's General Hospital, Cheverly, Md.

"Laboratory and Clinical Observations with a New Sulfonylurea" – Abraham A. Silver, Henry Wishinsky, Raymond F. Caplan, and Clifton Monk, The Sinai Hospital, Baltimore, Md.

Summary: Peter H. Forsham, University of California Medical Center, San Francisco, Calif.

THE VAGINA

Friday, April 10 and
Saturday, April 11, 1959

Conference Chairman: Warren R. Lang
Jefferson Medical College, Philadelphia, Pa.

FRIDAY, APRIL 10, 1959

VAGINAL ANATOMY AND PHYSIOLOGY

Session Chairman: F. Bayard Carter
Duke University School of Medicine, Durham, N. C.

9:00 A.M. -

Greetings from the Academy - Robert L. Kroc, Chairman, Section of Biological and Medical Sciences, The New York Academy of Sciences, New York, N. Y.; Warner-Lambert Research Institute, Morris Plains, N. J.

Opening Remarks - Warren R. Lang, Jefferson Medical College, Philadelphia, Pa.

"Embryology and Anatomy of the Vagina" - Lemen J. Wells, Dept. of Anatomy, University of Minnesota School of Medicine, Minneapolis, Minn.

"Observations on the Gross and Microscopic Anatomy of the Vagina" - Kermit E. Krantz, Medical Center, University of Arkansas, Little Rock, Ark.

"Studies on Vaginal Enzymology" - William H. Fishman and George W. Mitchell, Tufts University School of Medicine, Boston, Mass.

"Histochemical Localization of Vaginal Oxidative Enzymes and Mucins in Rats Treated with Estradiol and Progesterone" - Charles G. Rosa, Jefferson Medical College, Philadelphia, Pa., and Joseph T. Velardo, Yale University School of Medicine, New Haven, Conn.

"Sensitivity of the Vagina to Estrogens, Genetics and Transmitted Differences" - William U. Gardner, Yale University School of Medicine, New Haven, Conn.

"The Modification of Estrogen-Induced Changes in Rat Vaginae with Steroids and Related Agents" - Richard A. Edgren, Division of Biological Research, G. D. Searle & Co., Chicago, Ill.

THE HUMAN VAGINA

Session Chairman: Abraham E. Rakoff
Jefferson Medical College, Philadelphia, Pa.

2:00 P.M. -

"The Qualitative Estimation of Free Amino Acids in Human Vaginal Secretions" - A. T. Gregoire, Warren R. Lang, and Kathleen Ward, Jefferson Medical College, Philadelphia, Pa.

"Studies on Vaginal Contents and Cells with Proton Magnetic Resonance" - Eric Odeblad, Sabbatsberg Hospital, Stockholm, Sweden.

"Synergism and Antagonism of Sex Steroids as Determined on the Vaginal Epithelium" - George L. Wied, Chicago Lying-In Hospital, Chicago, Ill.

"A Study of Döderlein's Vaginal Bacillus" - Charles A. Hunter, Jr. and Keith Long, University of Kansas Medical Center, Kansas City, Kans.

"The Structure and Bacteriology of the Premenarchal Vagina" - John W. Huffman, Northwestern University Medical School, Chicago, Ill.

"Abdominovaginal Electric Potential Differences in the Menstrual Cycle" - Langdon Parsons, Medical Associates of the Massachusetts Memorial Hospitals, Boston, Mass.

SATURDAY, APRIL 11, 1959

VAGINAL INFECTIONS

Session Chairman: R. Gordon Douglas,
Cornell Medical Center, New York, N. Y.

9:00 A.M. -

"Factors Relating to Mycotic and Trichomonad Infections" - H. Close Hesseltine, Chicago Lying-In Hospital, Chicago, Ill.

"Metabolic Studies on *Trichomonas vaginalis*" - Ralph Wellerson, George Doscher and Alfred B. Kupferberg, Ortho Research Foundation, Raritan, N. J.

"The Nonspore-Forming Anaerobic Bacteria of the Vagina" - Claudius P. Jones, Duke University Medical Center, Durham, N. C.

"Vaginal Fungi" - F. Bayard Carter, Duke University School of Medicine, Durham, N. C.

"*Hemophilus vaginalis* Vaginitis" - Herman L. Gardner and Charles D. Dukes, School of Medicine, Baylor University, Houston, Texas.

"*Hemophilus vaginalis* and Nonspecific Vaginitis" - Andre Heltai, Methodist Hospital, Brooklyn, N. Y.

THE VAGINA IN REPRODUCTION: MISCELLANEOUS

Session Chairman: Herbert H. Thomas
Medical College of Alabama, Birmingham, Ala.

2:00 P. M. -

"The Vagina and Infertility" - Edward T. Tyler, Chairman, Postgraduate Infertility Course, University of California School of Medicine, Los Angeles, Calif.

"The Sexual Response Cycle of the Human Female - Vaginal Lubrication" - William H. Masters and Matthew W. Noall, Washington University School of Medicine, St. Louis, Mo.

"The Permeability of the Vaginal Mucosa" - Carl G. Hartman, Ortho Research Foundation, Raritan, N. J.

"Histopathology of Surgically Excised Lesions of the Vagina" - Cary M. Dougherty, Louisiana State University School of Medicine, New Orleans, La.

"Effects of Antigens on the Basal Cells of the Vaginal Smear" - John Graham, Roswell Park Memorial Institute, Buffalo, N. Y.

"Vaginal Keratinization *in Vitro*" - Raymond H. Kahn, University of Michigan Medical School, Ann Arbor, Mich.

Brief Summary - Warren R. Lang, Jefferson Medical College, Philadelphia, Pa.

ORGANIZING COMMITTEE

Chairman: Warren R. Lang

F. Bayard Carter
R. Gordon Douglas
A. B. Kupferberg
A. E. Rakoff
Herbert H. Thomas
Albert Tyler
Edward T. Tyler

SECTION OF CHEMICAL SCIENCES

MOLTEN SALTS

Monday, April 13

Tuesday, April 14 and

Wednesday, April 15, 1959

Conference Chairman: Benson R. Sundheim
New York University, Washington Square College,
New York, N.Y.

PROGRAM

MONDAY, APRIL 13, 1959

Session Chairman: Benson R. Sundheim
New York University, Washington Square College,
New York, N.Y.

9:00 A.M. –
Greetings from the Academy – Karl A. Folkers, Chairman, Section of Chemical Sciences, The New York Academy of Sciences, New York, N.Y.; Merck and Company, Inc., Rahway, N.J.

Opening Remarks – Benson R. Sundheim, New York University, Washington Square College, New York, N.Y.

"X-Ray and Neutron Diffraction Studies of Some Molten Salts" – M.D. Danford, P.A. Agron, Max A. Bredig, and Henry Levy, Oak Ridge National Laboratory, Oak Ridge, Tenn.

"Equations of State for Molten Salts" – G. E. Blomgren, National Carbon Research Laboratories, Cleveland, Ohio.

"Constitution of Molten Mercuric Halides" – George J. Janz and James D. McIntyre, Rensselaer Polytechnic Institute, Troy, N.Y.

"Some Aspects of the Thermodynamics of Molten Salts" – John O'Malley Bockris, D. Inman, G.J. Hill and L. Young, University of Pennsylvania, Philadelphia, Pa.

Session Chairman: Dieter Gruen
Argonne National Laboratories,
Lemont, Ill.

2:00 P.M. –

"Activity Coefficients in Molten Salts" – Haakon Flood, E. Aukrust, B. Jörge, and T. Forland, University of Trondheim, Trondheim, Norway.

"A Quasi-Lattice Model of Molten Reciprical Salt Systems – Milton Blander and J. Braunstein, Oak Ridge National Laboratories, Oak Ridge, Tenn.

"Activity Coefficients in Molten Salts" – S.N. Flengas, Department of Mines and Technical Surveys, Division of Mineral Dressing and Process Metallurgy, Ottawa, Canada.

"Cryosocopy in Molten Salt Systems"–K.J. McLeod and F.E.W. Wetmore, University of Toronto, Toronto, Canada.

TUESDAY, APRIL 14, 1959

Session Chairman: John O'Malley Bockris
University of Pennsylvania,
Philadelphia, Pa.

9:00 A.M. –

"Thermodynamic Properties of Solutions of Cerium Chloride in Molten Alkali Halides" – Seymour Senderoff, George Mellors and Robert Bretz, National Carbon Research Laboratories, Cleveland, Ohio.

"The U – U(III) Potential in LiCl/KCl Eutectic" – Robert Osteryoung, Rensselaer Polytechnic Institute, Troy, N.Y. and Dieter Gruen, Argonne National Laboratories, Lemont, Ill.

"Thermodynamics of Molten Binary Chloride Mixtures Calculated from the Phase Diagrams." – James Egan, Brookhaven National Laboratory, Upton, Long Island, N.Y.; Benjamin Chu, Dept. of Chemistry, Cornell University, Ithaca, N.Y.

"The Cryolite Situation" – L. M. Foster, Alcan Research Laboratories, Aluminum Company of America, New Kensington, Pa.

Session Chairman: George J. Janz
Rensselaer Polytechnic Institute
Troy, N.Y.

2:00 P.M. –

"Absorption Spectra of Fused Salt Solutions" – G. Pedro Smith and Charles Boston, Oak Ridge National Laboratory, Oak Ridge, Tenn.

"Absorption Spectra of Transuranic Elements in Molten Salts" – Dieter H. Gruen and Robert Macbeth, Argonne National Laboratories, Lemont, Ill.

"The Configuration of Ions in Molten Salts" – Benson R. Sundheim and George Harrington, New York University, Washington Square College, New York, N.Y.

"Isothermal and Isopiestic Decomposition of Potassium Perchlorate and Potassium Chlorate" – Kurt Stern, A. E. Harvey, C. J. Wassink and T. A. Rogers, University of Arkansas, Fayetteville, Ark.

WEDNESDAY, APRIL 15, 1959

Session Chairman: Daniel Cubicciotti
Stanford Research Institute
Menlo Park, Calif.

9:00 A.M. –

"Isotope Enrichment by Electromigration in a Mixture of Molten $RbNO_3$ and $LiNO_3$" – Arnold Lunden, Chalmers Institute of Technology, Gothenburg, Sweden.

"Interionic Friction Coefficients in Molten Salts" – Richard Laity, Princeton University, Princeton, N.J.

"The Mobility of the Ions in Pure Fused Silver Chloride as a Function of Temperature" – Frederick Duke, Iowa State College, Ames, Iowa.

"Reference Electrodes and Overvoltage Measurements in Molten Salts" – R. Piontelli, Politecinico Milano, Milan, Italy.

Session Chairman: Frederick Duke
Iowa State College
Ames, Iowa

2:00 P.M. –

"Composition of Vapors in Equilibrium with Salts at High Temperatures" – Joseph Berkowitz and William A. Chupka, Argonne National Laboratories, Lemont, Ill.

"Solubilities of Salts in Metals" – Sam J. Yosim and E. B. Luchsinger, Atomics International, Canoga Park, Calif.

"Electrolysis of Liquid $Bi/BiCl_3$ Mixtures" – Daniel Cubicciotti, Stanford Research Institute, Menlo Park, Calif. and Norman L. Lofgren, Chico State College, Chico, Calif.

Closing Remarks: Benson R. Sundheim, New York University, Washington Square College, New York, N.Y.

NEW MEMBERS

LIFE MEMBERSHIP

Houle, Joseph O., D.C., Neurophysiology. Private Practice, Montreal, Canada.

SUSTAINING MEMBERSHIP

Cotter, James Joseph, M.D., Medicine, Practicing Surgeon, Private Practice, Elmhurst, N. Y.

van den Bosch, F. J. G., Ph.D., Physics. Director, Centre pour Electromicroscopie, Antwerp, Belgium.

ACTIVE MEMBERSHIP

Alberico, Anthony M., M.D., Internal Medicine. Resident in Medicine, Jefferson Medical College Hospital, Philadelphia, Pa.

Alexander, Merton J., M.D., General Surgery. Staff Physician in Medical Oncology, City of Hope Medical Center, Duarte, Calif.

Anderson, John A., Ph.D., Pediatrics. Professor & Head, Department of Pediatrics, University of Minneapolis, Minn.

Atonna, Guy B., M.D., Surgery, Genocology, Medicine. Physician & Surgeon, Private Practice, Douglas, Ariz.

Baca, D. E., M.D., General Surgery. Practicing General Surgeon & General Practice, Papillion, Nebr.

Barr, Martin, Ph.D., Pharmaceutical Education. Associate Professor of Pharmacy, Philadelphia College of Pharmacy & Science, Philadelphia, Pa.

Barton, William Karl, M.D., Research, Biological & Medical Sciences. Private Practice, St. Petersburg, Fla.

Bergen, Stanley Silvers, Jr., M.D., Internal Medicine. Assistant to the Director of Medical Service, St. Luke's Hospital, New York, N. Y.

Berman, Leo H., M.D., Psychiatry. Private Practice, Norwalk, Conn.

Berry, John W., M.D., Internal Medicine. Assistant Professor of Medicine, St. Louis University School of Medicine, St. Louis, Mo.

Bethell, Frank H., M.D., Internal Medicine. Professor of Internal Medicine, University of Michigan, Ann Arbor, Mich.

Bloomquist, Edward R., M.D., Anesthesiology. Private Practice, Glendale, Calif.

Borenstein, Morris V., M.D., Psychiatry. Private Practice, Agawam, Mass.

Brew, Barbara Ann, M.D., Obstetrics & Gynecology. Instructor, Louisiana State University Medical School, New Orleans, La.

Burns, Neal M., Ph.D., Physiological & Experimental Psychology. Senior Psychologist, Air Crew Equipment Laboratory, Philadelphia, Pa.

Carlson, Arthur S., M.D., Pathology. Associate Pathologist, Community Hospital, Glen Cove, N. Y.

Consentino, Albert B., M.D., Medicine. Private Practice, Haverhill, Mass.

Cornelison, Floyd S., Jr., M.D., Psychiatry. Assistant Professor, University of Oklahoma School of Medicine, Oklahoma City, Okla.

Cutler, Arthur, B.A., Biology, Endocrinology. Laboratory Technician, New York University College of Medicine, New York, N. Y.

Daue, Edwin Oliver, Jr., M.D., Abdominal Surgery. Associate in Surgery, Harrisburg Polyclinic Hospital, Harrisburg, Pa.

Davis, Charles Steven, M.D., Internal Medicine. Resident Physician, University of Illinois, Chicago, Ill.

Davolos, Dominick D., M.D., Medicine, Cardiology. Private Practice, Cincinnati, Ohio.

De Carvalho, Sergio, Ph.D., Hematology, Cancer. Hematologist & Associate Director of Laboratories, Doctors Hospital, Cleveland, Ohio.

De Nyse, Donald L., M.D., Internal Medicine, Cardiology. President of Medical Staff, Roger Williams General Hospital, Cranston, R.I.

Desmond, Thomas C., Hon., L.H.D., Astronomy, Geology. Retired, Former New York State Senator, Newburgh, N. Y.

Dobson, Catherine L., M.D., Obstetrics. Private Practice, Chicago, Ill.

Efrati, Pinhas, M.D., Medicine, Hematology. Director, Medical Department, Kaplan Hospital, Rehovoth, Israel.

Evans, David R., Ph.D., Physiology. Assistant Professor of Biology, Johns Hopkins University, Baltimore, Md.

Eyquem, André, M.D., Immunology, Hematology. Chef de Laboratoire à l'Institut Pasteur, Paris, France.

Fitzgerald, Maurice D., M.D., Clinical Radiology. Private Practice, Evansville, Ind.

Friedman, Irving A., M.D., Hematology. Clinical Assistant Professor, Chicago Medical School, Chicago, Ill.

Gallai, Zoltan, M.D., Dermatology. Physician, Notre Dame Hospital, Montreal, Canada.

Goodgold, Joseph, M.D., Electromyography. Associate Clinical Professor, New York University - Bellevue Medical Center, New York, N. Y.

Gordon, Lillian, M.D., Psychology. Private Practice, N. Y.

Gripkey, Clarence A., M.D., Thyroid & Metabolic Diseases, Surgical Staff, St. Margaret's Hospital, Kansas City, Kans.

Gross, Rudolf, M.D., Hematology, Cancer. Chief Physician, Medizinische Universitäts Klinik, Marburg/Lahn, Germany.

Heine, William I., M.D., Internal Medicine. Associate Attending Physician, Albert Einstein Medical Center, Philadelphia, Pa.

Herron, James R., M.D., Obstetrics & Gynecology. Private Practice, Camden, N.J.

Heseltine, William Wasney, M.A., Pharmacology. Regional Director of Clinical Research, E. R. Squibb & Sons, Liverpool, England.

Hill, Allen Malcolm, M.D., Pediatric Teaching. Instructor, Harvard Medical School, Boston, Mass.

Hodge, Clare C., M.D., Surgery. Private Practice, Bryn Mawr, Pa.

Hodsden, Stephen Riley, M.D., Neurological Diseases. Private Practice-Generalist, Baltimore, Ohio.

Hoffman, John William, M.D., Pathology. Chief Resident, McClaren General Hospital, Flint, Mich.

Isaacs, Bertha L., M.D., Internal Medicine. Private Practice, Chicago, Ill.

Jacobs, John, M.D., Neurological Surgery. Private Practice, Beverly Hills, Calif.

Jacobsen, Edwin, Jr., B.S.C.E., Physics. Builder & Developer, Bethesda, Md.

Johannet, Pierre, M.D., Psychiatry. Senior Staff Psychiatrist, The James Jackson Putnam Children's Center, Boston, Mass.

Kabasakalian, Peter, Ph.D., Chemistry. Chemist, Schering Corporation, Bloomfield, N.J.

Kaighin, Hall Young, M.Ch.E., Utilization of Agricultural By-Products or Waste. Vice-President, Product Development, New York, N. Y.

Kaplan, Eugene H., M.D., Psychiatry. Private Practice, Great Neck, N. Y.

Katz, Stanley S., M.A., Biology. Assistant Professor of Biology, Quinnipiac College, Hamden, Conn.

Keller, John M., M.D., Infertility. Gynecologist-Obstetrician, Williston Clinic, Williston, N. Dak.

Kessler, Donald L., M.D., Internal Medicine. Physician, St. Joseph's Hospital, Chicago, Ill.

Kessler, Israel, M.D., Arthritis. Private Practice, Washington, D. C.

Kinsey, Dera, M.D., Hypertension. Associate, Massachusetts Memorial Hospital, Boston, Mass.

Larsen, Ralph Michael, M.D., Surgery. Associate Professor of Clinical Surgery, Vanderbilt University School of Medicine, Nashville, Tenn.

Lasky, Solomon S., M.D., Biological & Medical Research, Private Practice, New York, N. Y.

Laufer, Annie, Ph.D., Endocrinology. Brooklyn Jewish Hospital, Brooklyn, N. Y.

Lawrence, William C., B.S., Internal Medicine. 4th-Year Veterinary Student, University of Pennsylvania, Philadelphia, Pa.

Lewis, Harvey A., M.D., Psychoanalysis. Associate Attending, Mt. Sinai Hospital, Los Angeles, Calif.

Lloyd, Leslie G., M.D., Clinical Neurology. Neurologist, Beverly Hills Clinic, Beverly Hills, Calif.

Lloyd, Robert P., M.D., Surgery. Private Practice, Fort Wayne, Ind.

MacInnis, Florence E., M.D., Tuberculosis. Private Practice, Kansas City, Mo.

Mantica, John Louis, M.D., Diabetes. Private Practice, Steubenville, Ohio.

Masin, Francis, M.D., Cytochemistry. Research Associate, Mt. Sinai Hospital, Los Angeles, Calif.

Menard, Oliver J., M.D., Medicine. Senior Consultant, Springfield Hospital, Springfield, Mass.

Mezey, Kalman C., M.D., Pharmacology of Cardiovascular Drugs. Director of Research, Merck, Sharp & Dohme Research Laboratories, Rahway, N. J.

Nador, George William, M.D., Medicine, Surgery. Medical Consultant, Los Angeles, Calif.

Nerwerla, Gerhard J., M.D., Medicine. School Physician, Waltham, Mass.

Niemtzow, Frank, M.D., Biology, Medical Sciences. Private Practice, Freehold, N. J.

Nodine, John H., M.D., Clinical Pharmacology. Assistant Professor of Medicine, The Hahnemann Medical College & Hospital, Philadelphia, Pa.

Obrebski, Jozef, Ph.D., Anthropology, Sociology. Private Practice, Hollis, N. Y.

Pardo-Menéndez, Victoriano, M.D., Pathology, Histology. Instructor in Histology, University of Havana, Havana, Cuba.

Parra, Francisco, M.D., Endocrinology. Research Fellow, Sloan-Kettering Institute for Cancer, New York, N. Y.

Parsons, Robert Louis, M.D., Cardiovascular Physiology. 3rd-Year Resident in Medicine, Presbyterian Hospital, Chicago, Ill.

Patterson, Stuart A., M.D., Medical Radiology. Private Practice, Fort Collins, Colo.

Pelz, Werner Peter, M.D., Arthritis. Private Practice, Charles City, Iowa.

Peterman, Earl A., M.D., Enzyme Research. Director of Laboratories, Woodward General Hospital, Detroit, Mich.

Pittman, Merry E., M.D., Cardiology. Industrial Physician, W. F. Schrafft & Sons, Boston, Mass.

Ramos, José M., M.D., Internal Medicine. Senior Physician, Newport Hospital, Newport, R. I.

Redo, S. Frank, M.D., Surgery. Assistant Attending Surgeon, The New York Hospital, New York, N. Y.

Rock, Erwin H., M.D., Otology Research. Clinical Instructor in Surgery, Albert Einstein College of Medicine, New York, N. Y.

Sarasin, Raymond, M.D., Radiology. Professor of Medicine, University of Geneva, Geneva, Switzerland.

Schramm, Frank, M.D., Obstetrics. Assistant, St. Lukes Hospital, Bethlehem, Pa.

Schwartz, Ira Stephen, M.D., Pathology. Intern, Long Island College Hospital, Brooklyn, N. Y.

Silver, Maurice J., M.D., Geriatrics. Private Practice, Brookline, Mass.

Simkins, Samuel, M.D., Endocrinology. Assistant Professor of Medicine, Hahnemann Medical College, Philadelphia, Pa.

Skahen, Richard, M.D., Pathology. Private Practice, Berkeley, Calif.

Slatkin, Marvin W., M.D., Medicine. Resident Dermatologist, Bellevue Hospital, New York, N. Y.

Söderström, Nils, M.D., Cardiology. Chief Physician, Karlstad Central Hospital, Karlstad, Sweden.

Soldo, Anthony T., Ph.D., Biochemistry. Microbiologist, Schering Corporation, Bloomfield, N. J.

Solworth, Lee, M.D., Surgery. Attending Surgeon, Englewood Hospital, Englewood, N. J.

Stone, Melvin M., M.D., Medicine. Private Practice, Dania, Fla.

Szucs, Murrill Michael, M.D., Biochemistry, Internal Medicine & Research, Youngstown, Ohio.
Uribe, Roberto De La Espriella, Medicine. Layman, Bogota, Columbia, South America.
Uvnäs, Börje K. M., M.D., Pharmacology. Head of Department, Karolinska Institutet, Stockholm, Sweden.
Waskow, Eleanor A., M.D., Internal Medicine. Private Practice, Phoenix, Ariz.
Weiner, Herbert, M.D., Neuropsychiatry. Assistant Professor, Albert Einstein College of Medicine, New York, N. Y.
Weiselberg, Hyman Morton, M.D., Radiology. Radiologist, Mary Immaculate Hospital, Jamaica, N. Y.
Weissgerber, Rudolph E., M.D., Medicine. Regional Scientific Director of E. R. Squibb & Sons, Munich, Germany.
Weygandt, Arthur S., B.S., Development. Special Assistant, Food Machinery & Chemical Corporation, New York, N. Y.
Widerman, Arnold, M.D., Pediatrics. Associate Pediatrician, Einstein Medical Center, Philadelphia, Pa.
Widra, Abe, Ph.D., Microbiology. Instructor, University of North Carolina Medical School, Chapel Hill, N. C.
Wiener, Israel, M.D., Allergic Disease. Private Practice, Detroit, Mich.
Wigser, A. M., M.D., Medical Science. Private Practice, Cincinnati, Ohio.
Wiland, Olin K., M.D., Pathology. Pathologist, Reid Memorial Hospital, Richmond, Ind.
Williams, Robert E., Ph.D., Chemistry. Research Supervisor, N M R-Structure Group, Pasadena, Calif.
Winckhofer, Robert C., B.S., Synthetic Polymer Applications. Engineer, Whippany, N. J.
Wing, Raymond, M.D., Medicine. Private Practice, Easton, Pa.
Woldow, Irving, M.D., Hematology. Hematologist, Albert Einstein Medical Center, Philadelphia, Pa.
Wurzel, Harold A., M.D., Blood Coagulation. Assistant Professor of Clinical Pathology, Hospital of the University of Pennsylvania, Philadelphia, Pa.
Zucker, Reuben, M.D., Medical Sciences. Private Practice, Orlando, Fla.

STUDENT MEMBERSHIP

Chambers, Donald A., A.B., Biochemistry & Physiology. Assistant in Chemistry, Columbia College, New York, N. Y.
Liss, Richard M., Medicine. Medical Student, New York University College of Medicine, New York, N. Y.